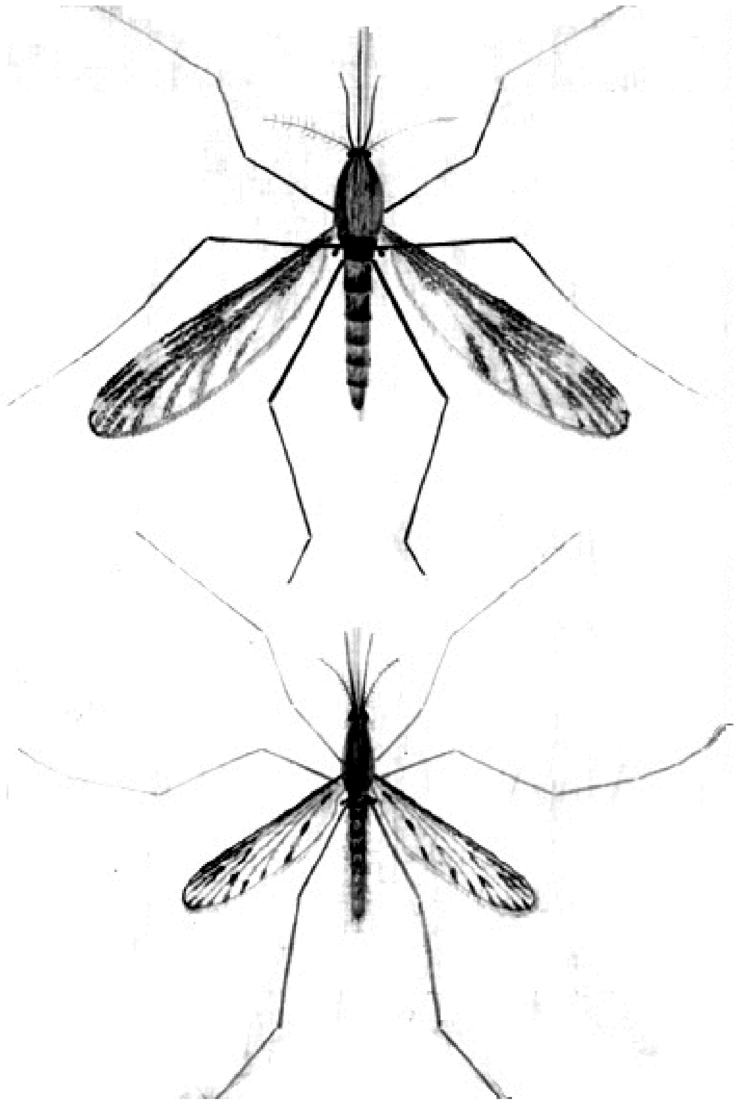
North Dakota Mosquito Surveillance 2003 Program



North Dakota
Department of Health

Division
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Acknowledgements

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for reviewing this document.

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2003 North Dakota Mosquito Surveillance Program

Mission

The North Dakota Department of Health (NDDoH) monitors the risk of possible infection from arboviral encephalitides that are known to occur in this region; western equine encephalitis (WEE), St. Louis encephalitis (SLE) and West Nile virus encephalitis (WNV). Currently, the surveillance program is concerned primarily with the mosquito species *Culex tarsalis*, the primary vector for WEE, SLE and WNV. As during previous surveillance periods, the state will focus activities on *Cx. tarsalis*, watching for increased numbers in the New Jersey Trap Network and actual virus activity using the CDC Light Trap Network to determine the need for control activities.

2003 Mosquito Trap Operators

Thank you to the following New Jersey and CDC Mosquito Trap Operators whose dedication and commitment to the North Dakota Department of Health Mosquito Surveillance Program made the 2003 program a success.
*** Indicates a CDC trapper.**

Jesse Handegard	Adams County	Kim Kibbel	Hettinger County	Jim Heckman	Renville County
Jeff Differding *	Barnes County	Kris Gentzkow	Kidder County	Jerry Lein	Richland County
Jean Mosser	Benson County	Tony Hanson	LaMoure County	Jen Malaterre	Rolette County
Bruce Kay	Billings County	Andy Gross	Logan County	Colleen Sundquist	Sargent County
Sue Brandvold	Bottineau County	Sandy Birst	McClean County	Dallas & Miraim Bold	Sheridan County
Brenda Rettinger	Bowman County	Nikki Medalen	McHenry County	Eliot Rhodes	Sioux County
Mel Fischer	Bureigh County	Marcus Lynn	McIntosh County	Brenda Rettinger	Slope County
Erica Schuller	Burleigh County	Robert Nelson	McKenzie County	Susan Heck	Stark County
Peter Willyard	Burke County	Keith Johnson	Mercer County	Skip Rapp	Stark County
Kristi Biewer *	Cass County	Dick Bechtel	Morton County	Denny Smith	Stark County
Elisha Kabanuk	Cass County	Vawnita Best	Morton County	Kevin Pavlish *	Stark County
Don Russiff	Cass County	Lance Elmer	Morton County	Greg Sund	Stark County
Brady Scribner	Cass County	Chad Stern	Morton County	Diane Jacobson	Steele County
Reed Wisenburger	Cass County	Feiring's Veterinary Service	Mountrail County	Jim Michael *	Stutsman County
Rob Gilseth	Cavalier County			Steve Reidburn *	Stutsman County
Terri Gustafson	Cavalier County	Julie Ferry	Nelson County	Terry Harland	Towner County
Robert Schaefer	Dickey County	Keith Johnson	Oliver County	Jim Anderson	Traill County
Dennis Lampert	Divide County	Tim Midboe	Pembina County	Brenda Stallman	Traill County
Kevin Pavlish	Dunn County	Kathy Johnson	Pembina County	Mike Huska	Walsh County
George Ritzke	Eddy County	Jeanette Mygland	Pierce County	Jim Heckman *	Ward County
Bev Voller	Emmons County	Myron Asleson *	Ramsey County	Jody Reinsch	Ward County
Jean Kulla	Foster County	Leroy Axdahl *	Ramsey County	Connie Haman	Wells County
Alvin & Betty Tescher	Golden Valley County	Alan McKay	Ramsey County	Loren Stoltz	Wells County
		Glen Furman	Ransom County	Dave Benth *	Williams County
Todd Hanson *	Grand Forks County	Rick Gillund	Ransom County	Gene Gafkjen	Williams County
Norman Schock	Grant County	Randy Seelig	Ransom County	Mike Melius	Williams County
Julie Ferry	Griggs County			Kurt Odegard	Williams County

North Dakota State Park New Jersey Trap Operators

Kathy Duttenhefner	ND Parks and Rec. Dept.	Jon Kwapinski	Ft. Ransom	John Tunge	Lake Sakakawea
		Richard Messerly	Ft. Stevenson	Dave Leite	Lake Sakakawea
Erik Dietrich	Beaver Lake	Dick Horner	Grahams Island	Helen Volk Schill	Lewis and Clark
		Henry Duray	Icelandic	Dick Horner	Shelvers Rec. Area
Dennis Clark	Cross Ranch	Byron & Tolly Holtan	Indian Hills Rec. Area	Steve Crandall	Turtle River
Chuck Erickson	Ft. Abraham Lincoln	Larry Hagen	Lake Metigoshe		

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Dear Reader:

The following document is the North Dakota Mosquito Surveillance 2003 Program Report including recommendations for 2004. It outlines the 2003 program based on policies and recommendations set forth by previous and present mosquito surveillance personnel.

The Division of Microbiology (NDPHL) and the Arbovirus Program supervisor have reviewed the Mosquito Surveillance 2003 report. Their experience and knowledge were requested to make recommendations for improvements in the 2003 and 2004 North Dakota Mosquito Surveillance Program. The recommendations are included in this report.

Please contact the North Dakota Mosquito Surveillance Program if you would like additional information.

Travis Schulz
Mosquito Surveillance Program Coordinator
October 2002 to August 2003

Table of Contents

2003 Mosquito Surveillance Program Overview

New Jersey Trap Network

The *2003 North Dakota Mosquito Surveillance Program* was enhanced with the addition of a full-time mosquito surveillance coordinator, onsite mosquito trap training, and mosquito speciation training. In addition, the state New Jersey Trap Network was expanded to include a total of 87 traps with at least one mosquito trap in every county, state park, and Indian reservations. The state network also included two New Jersey Traps in each urban area with a population greater than 7,000 citizens.

Mosquito surveillance program activities began in January with the solicitation of New Jersey Light Trap and CDC Miniature Light Trap operators. Prospective trap operators were contacted regarding participation in the *2003 North Dakota Mosquito Surveillance Program*. At the time of contact, trap supplies for each trapping location were determined.

During February and March, mosquito surveillance personnel conducted on-site mosquito trap training sessions. The training sessions covered the goals and objectives of the *2003 North Dakota Mosquito Surveillance Program*, provided training about New Jersey Mosquito Trap maintenance and placement, and established rapport between the New Jersey Trap operators and the mosquito surveillance program personnel. During the training sessions, new or replacement traps and additional supplies were issued.

During the months of April and May, mosquito speciation training sessions were conducted for personnel supervising local New Jersey Trap Networks. The training sessions covered mosquito ecology, genera characteristics and other key information.

In May, an equine in Cass County tested positive for infection with West Nile virus, prompting the state program to begin mosquito surveillance activities on May 18, a full two weeks before the original anticipated start date.

CDC Miniature Light Trap Network

In 2003, the CDC Miniature Light Trap Network was created to include nine locations within the state. CDC Miniature Light Traps were issued during the mosquito speciation training sessions. Environmental health personnel were solicited to assist in operating remote CDC traps for the North Dakota Mosquito Surveillance Program. Trap operator participation was phenomenal throughout the 2003 season, with all traps reporting each week of operation.

Conclusion of 2003 Program:

The *2003 North Dakota Mosquito Surveillance Program* was successful. The program met or expanded upon the goals established in the mission statement. Mosquito populations, specifically the *Cx. tarsalis*, and arbovirus activity was successfully monitored statewide throughout the season. In addition to population and arbovirus monitoring, the following objectives were met:

- Training was provided for trap placement and mosquito identification,
- Mosquito trap placement pamphlets and identification quick reference keys were developed and distributed throughout the state,
- Relationships were established between mosquito populations and local climate events,
- All state New Jersey Traps were assigned a tracking number for easier inventory,
- Global Positioning System (GPS) coordinates of all New Jersey Mosquito Traps were established.
- A video was developed for future distribution.

Mosquito Surveillance

Program Background
Since 1975, the North Dakota Department of Health has periodically monitored mosquito populations throughout the state. The Mosquito Surveillance Program traditionally has been activated and/or reactivated following arboviral outbreaks or flooding incidences in various locations throughout the state.

The program was first initiated in 1975 following an outbreak of Western Equine Encephalitis (WEE) and St. Louis Encephalitis (SLE). In 1977, the program was officially formed under the title of North Dakota Arboviral Encephalitis Surveillance Program and housed by the Division of Environmental Sanitation and Food Protection. This program was responsible for equine and human arbovirus surveillance and ran until 1989, when it was canceled due to lack of funding.

The program was reinstated under the name of North Dakota Mosquito Surveillance Program in 1994 in response to flooding of the Red River in 1993. This program was, and currently is, housed within and operated by the Division of Microbiology (North Dakota Public Health Laboratory) in Bismarck, ND. The program ran until 1997, when it was once again canceled due to lack of funding.

In 2000, the North Dakota Mosquito Surveillance Program was once again reinstated in response to the 1999 West Nile virus (WNV) outbreak in New York. During the years of 2000 and 2001, no WNV activity was seen within North Dakota. However, in 2002, North Dakota had its first confirmed cases of WNV in birds, horses and humans. In addition to the confirmed avian and mammalian cases of WNV, a mosquito pool from Grand Forks County tested positive for WNV.

The 2003 program expanded to include a network of 87 New Jersey Mosquito Traps and 18 CDC Miniature Light Mosquito Traps providing full coverage across North Dakota. With the expansion of the program, one full-time mosquito surveillance coordinator was added. The program also included three full-time summer personnel responsible for mosquito speciation and counting, as well as mosquito-associated administrative duties.

New Jersey Mosquito Trap Network

Introduction

The New Jersey Mosquito Trap Network (Appendix A, Fig. 4), has been in place periodically since the North Dakota Mosquito Surveillance Programs inception in 1975. The network is primarily volunteer based. In recent years, it has grown to incorporate various city, county and state organizations, as well as one federal agency.

Traditionally, the New Jersey Mosquito Trap Network volunteers either approach the North Dakota Department of Health (NDDoH) or are solicited to participate in the program. Each volunteer agrees to install a New Jersey Mosquito Trap (Appendix A, Fig. 1) in a suitable location at the beginning of mosquito season, generally late May or early June. Using a programmable timer, the trap is set to operate between the hours of 8:30 p.m. and 7 a.m. seven nights a week. At the end of the seven-day period, usually Sunday night to Monday morning, the samples are collected and sent to the North Dakota Public Health Laboratory (NDPHL) in Bismarck for counting and speciation. This process repeats itself weekly until the end of mosquito season, generally near the end of September.

Once the samples arrive at the NDPHL, the mosquito surveillance personnel sort the mosquitoes into sex and genera. Since male mosquitoes do not bite, they are of little health concern. However, male mosquitoes do hatch first, and increased numbers may indicate a future female mosquito population boom. The female mosquitoes are separated into three genera - *Anopheles*, *Aedes*, *Culex*, and *Others* - and enumerated.

The NDDoH monitors the genus *Anopheles* due to its association with malaria and, more recently but to a much lesser extent, to West Nile virus (15).

The *Aedes* genera of mosquito are of a public health concern in North Dakota due to their vast numbers and association with illnesses such as dog heartworm, LaCrosse encephalitis (LCE), Eastern Equine encephalitis (EEE), Western Equine encephalitis (WEE), California encephalitis (CAE), and West Nile virus (WNV) (15). Although *Aedes vexans* has been shown to be capable of laboratory transmission of WNV, its mammalian feeding preferences decrease its potential as an enzootic vector for WNV (22).

The mosquito of greatest public health concern in North Dakota is the genus *Culex*. The enzootic transmission cycles of WNV and other arboviruses in North Dakota are conceptually identical with *Culex* vectors, transmitting virus among passerine avian hosts (22). All species of *Culex* found in North Dakota are competent vectors of SLE, WEE and WNV. The species most commonly associated with encephalitis in North Dakota is *Culex tarsalis* (15), a principal arbovirus vector in rural agricultural ecosystems (22).

New Jersey Mosquito Trap Network

2003 Results
In 2003, 1,255 New Jersey Mosquito Trap collections were made during the 19-week mosquito surveillance season. These 1,255 collections resulted in 935,598 total mosquitoes collected, with a weekly per trap average of 122.59. The highest mosquito counts were made during the third week of July. However, the highest *Culex tarsalis* counts were made during the fourth week of July.

Table 1:

Weekly Totals for the 2003 North Dakota Mosquito Surveillance Program

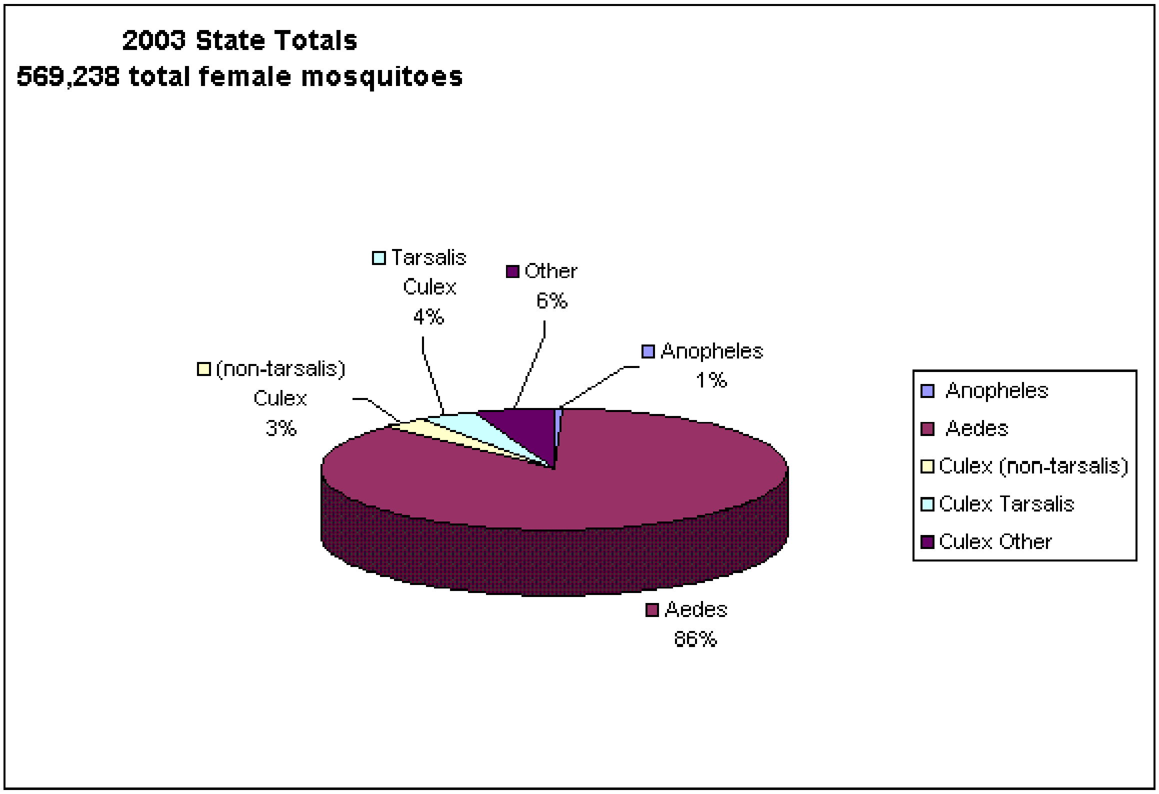
Week	Male	Female						Total Mosquitoes	Sites Reported & Counted
		Anopheles	Aedes	Culex (non-tarsalis)	Culex Tarsalis	Other	Total Female		
May 19-24	3321	35	5306	267	4	969	6581	9902	38
May 25-June 1	45624	17	17714	2551	154	969	21405	67029	64
June 2-8	74524	16	43699	3316	61	2246	49338	123862	74
June 9-15	41608	113	63485	4748	147	5086	73579	115187	74
June 16-22	36134	213	50620	1279	248	5519	57879	94013	76
June 23-29	9234	80	10957	515	511	1389	13452	22686	80
June 30-July 6	16452	357	42992	1116	1197	1496	47158	63610	72
July7-13	11145	282	41094	370	1044	1569	44359	55504	77
July 14-20	23859	333	81991	824	2933	805	86886	110745	71
July 21-27	30703	364	64560	322	5066	1301	71613	102316	67
July28-Aug3	14661	254	29321	160	2319	385	32439	47100	75
Aug 4-10	4133	461	21013	239	3433	433	25579	29712	66
Aug 11-17	6238	379	11434	704	2698	644	15859	22097	73
Aug 18-24	3642	431	6728	330	2127	680	10296	13938	69
Aug 25-31	3368	262	2651	204	958	2006	6081	9449	62
Sept 1-7	2912	278	3960	238	469	1893	6838	9750	63
Sept 8-14	1513	38	1592	71	94	2247	4042	5555	58
Sept 15-21	579	15	215	13	71	1391	1705	2284	54
Sept 22-28	303	3	14	0	6	1411	1434	1737	42
Total	329953	3931	499346	17267	23540	32439	576523	906476	1255

Totals include all traps reported for that week, including the state parks.

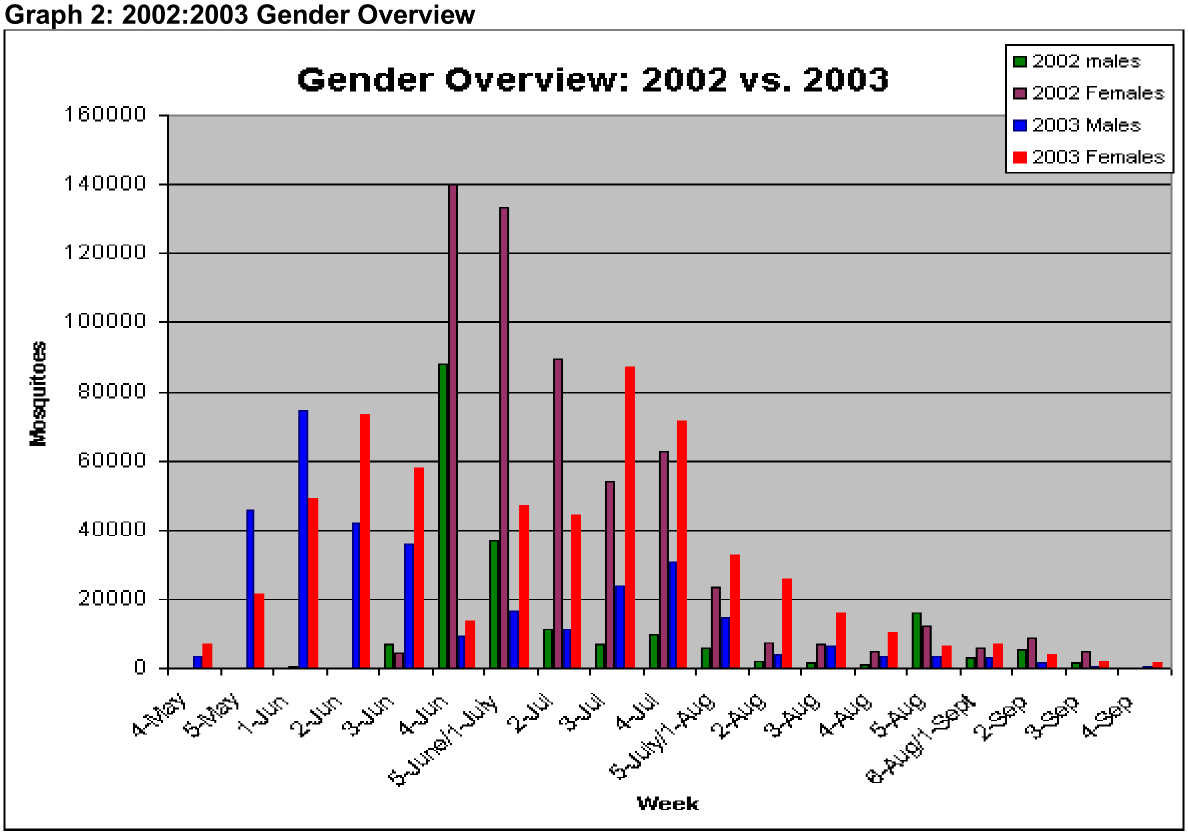
Traps not included were not reported for the week or were too wet to count.

New Jersey Mosquito Trap Network

Graph 1: 2003 Female Mosquito Overview



Graph 2: 2002:2003 Gender Overview



CDC Miniature Light Mosquito Trap Network

Introduction

Records indicate that the North Dakota Mosquito Surveillance Program has used the CDC Miniature Light Mosquito Trap (Appendix A, Fig. 2) since the programs 1975 inception. Due to the need for carbon dioxide (CO_2) as bait and shipping coolant, these traps are not deployed as extensively as the New Jersey Mosquito Traps.

The CDC Miniature Light Mosquito Trap is a battery-operated CO_2-baited trap that allows collection of mosquito specimens for laboratory testing. The traps are set up in suitable mosquito trapping locations, baited with CO_2 and collected as early as possible the next morning. The samples are then placed on ice to preserve any virus present and shipped to the NDPHL for speciation. At the laboratory, the specified species are separated and placed in pools of no more than 50 mosquitoes. The pools are then tested using the Nucleic Acid Sequence Based Assay (NASBA®, Biomeriuex, Durham, North Carolina) molecular amplification procedure and viral cultures to determine arbovirus presence within a mosquito pool.

In 2003, the CDC Miniature Light Mosquito Trap Network (Appendix A, Fig. 5) expanded to include 18 CDC Miniature Light Mosquito Traps deployed in nine locations throughout the state. On the night of July 1, the CDC trap network began its first night of operation. The network was then activated once a week, usually Tuesday night, for a 13-week period with the final trapping date of September 23.

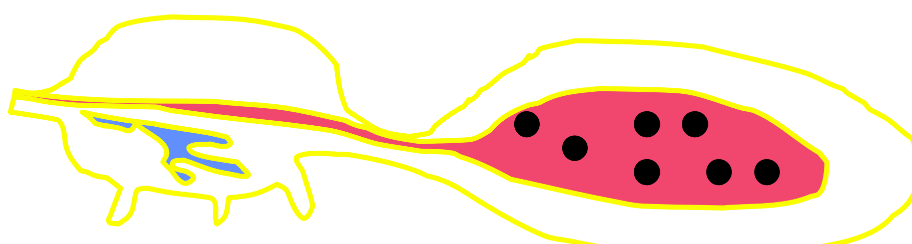
Arbovirus Information

Viruses designated as arboviruses, or arthropod-borne viruses, are viruses spread by blood-feeding insects. The blood-feeding insect most commonly implicated in the spread of arboviruses is the mosquito. The mosquito has been linked to such diseases as yellow fever, malaria and numerous encephalitides.

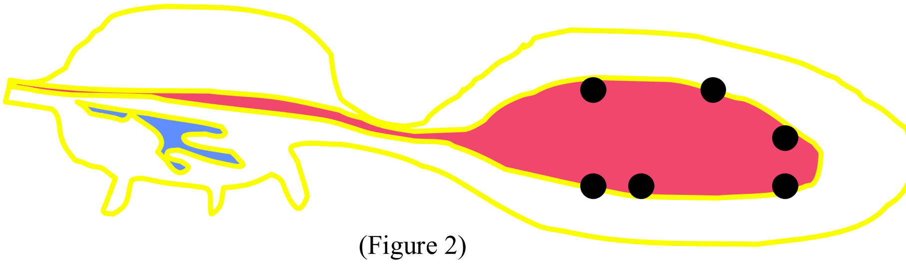
Not all mosquitoes are vectors; vehicles in the transmission of arthropod borne diseases. This is due in large part to mosquito species-specific meal preference. Male mosquitoes do not lay egg; therefore, they do not require a blood meal and feed almost exclusively on nectar. On the other hand, most female mosquitoes require a blood meal, but some species may prefer to feed from cold-blooded prey, whereas another species may prefer to feed from warm-blooded prey. Within the group of mosquitoes that prefer warm-blooded prey, some may prefer to take their blood meal from avians, humans or other mammals. However, the mosquitoes' warm-blooded prey preference may not be exclusive. In this case, the mosquito is considered an opportunistic feeder. This non-preferential or opportunistic feeding characteristic prompts the spread of arboviruses by these mosquitoes (15).

Recently, the encephalitis of greatest public health concern in the continental United States has been West Nile virus. Discovered in the West Nile region of Uganda in 1937, WNV first appeared in New York in 1999 (19). Since that time, the virus has been steadily making its way westward across the North American continent, appearing in North Dakota during the summer of 2002 (5).

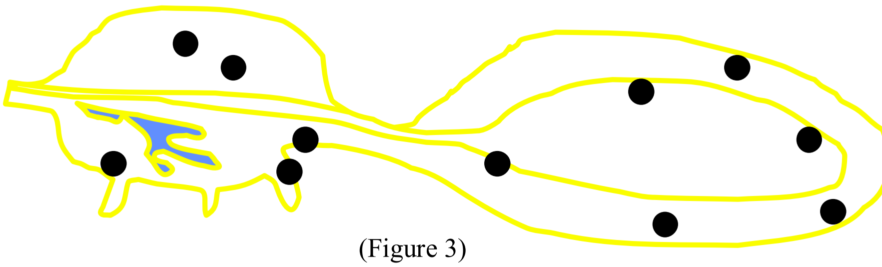
Currently, 36 species of mosquito are considered indigenous to the state of North Dakota. Of the 36 North Dakota species, 12 are known carriers of West Nile virus (11, 21). Mosquitoes carrying WNV can be divided into two groups: competent vectors and non-competent vectors (12). A competent vector of WNV is based on information gathered in both the field and laboratory studies. After initial ingestion, the WNV requires seven to 10 days of incubation within the mosquito to become pathogenic. During this time period, the virus multiplies, moves from the mosquito's gut to the gut wall, into surrounding body tissues, and finally into the salivary glands. Once the virus has infected the salivary glands, it can be transmitted to a host. Figures 1-4 depict this process. If the mosquito is considered a non-competent vector species, the virus migrates much more slowly to, or does not infect, the salivary glands and therefore is not readily transmitted to future blood-meal hosts (12).



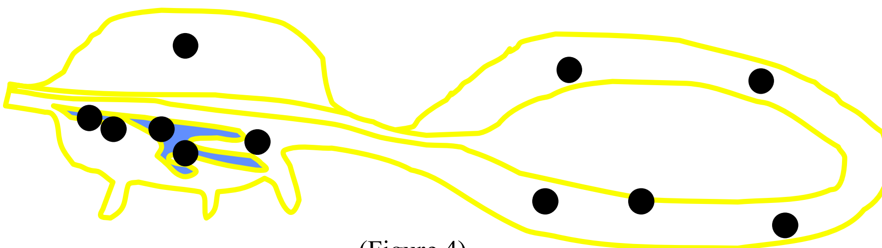
(Figure 1)
Virus in blood meal,
mosquito not infected.



(Figure 2)
Mosquito infected,
but limited to mid-gut.



(Figure 3)
Virus disseminated to
hemocoel, but salivary glands
not infected.



(Figure 4)
Virus in Salivary glands ready
to be transmitted.

* Figures reprinted from PowerPoint presentation by U.S. Army Medical Research Institute of Infectious Diseases, Fort Dietrick, Maryland

The North Dakota Mosquito Surveillance Program identifies species from the *Aedes*, *Culex* and *Anopheles* genera of mosquitoes. The *Culex* genus, particularly the *tarsalis* species, is the targeted vector in North Dakota for WNV, as well as other viral encephalitides (5, 13, 17). The population of this mosquito and other species is directly related to weather patterns, including temperature and precipitation. Additional studies have shown that the probability of the *Culex tarsalis* mosquito transmitting WNV is dependent on temperature (12).

This document will discuss WNV, as well as other viral encephalitides carried by mosquitoes, and will provide information about the *2003 North Dakota Mosquito Surveillance Program*, including mosquito counts, weather patterns and infection rates of WNV in North Dakota.

Arbovirus Testing

2003 West Nile Virus
Background

West Nile virus is named after the West Nile region of Uganda where it was first discovered in 1937. Common in many parts of the world, WNV virus had not been seen in the Northern Hemisphere until late summer 1999 (19). First appearing in New York, WNV has been spreading west across the continent and, by 2002, had appeared in 44 states, Canada, and the Cayman Islands (12).

Although only a small proportion of people infected with WNV display symptoms, WNV can cause encephalitis (an inflammation of the brain) and meningitis (inflammation of the brain and spinal cord) in humans and other animals. Symptoms of a WNV encephalitic infection include neck stiffness, confusion, loss of consciousness, tremors, convulsions, muscle weakness, paralysis, comas, permanent brain damage and possibly death (2).

Results

In 2003, 96 mosquito pools were tested for West Nile virus. Of the 96 pools tested, 11 tested positive for the presence of WNV using the NASBA® procedure.

Table 2: NASBA Results for Mosquito Collections for 2003

Location	County	Date Collected	Number of Mosquitoes Tested	Number of Mosquitoes Collected	Date Tested	Trap #	NASBA Result
Valley City	Barnes	7/15/2003	50	155	7/29/2003	1	Positive
Jamestown	Stutsman	7/30/2003	50	89	8/7/2003	1	Positive
Valley City	Barnes	7/30/2003	50	142	8/7/2003	1	Positive
Williston	Williams	7/30/2003	14	14	8/7/2003	2	Positive
Valley City	Barnes	8/7/2003	50	100	8/8/2003	2	Positive
Williston	Williams	8/7/2003	50	73	8/8/2003	2	Positive
Bismarck	Burleigh	8/20/2003	15	15	10/16/2003	1	Positive
Grand Forks	Grand Forks	8/20/2003	26	26	10/16/2003	1	Positive
Grand Forks	Grand Forks	8/27/2003	27	27	10/16/2003	1	Positive
Valley City	Barnes	8/27/2003	13	13	10/17/2003	1	Positive
Valley City	Barnes	8/27/2003	42	42	10/17/2003	2	Positive

Arbovirus Testing

2003 Western Equine Encephalitis

Background
Western Equine encephalitis is found in states west of the Mississippi River, Wisconsin and Illinois. Major outbreaks in equines occurred throughout the 1930s, and large human outbreaks occurred in 1952, 1958, 1965, and 1975 (15).

Cases of WEE are generally concentrated in the young age groups. Human mortality rates range from 1% to 5% with horse mortality rates considerably higher (15).

Results
2003 results are pending for mosquito pools tested for WEE.

Western Equine encephalitis was not considered a major agricultural or public health threat in North Dakota during 2003 by the Centers for Disease Control and Prevention and the North Dakota Department of Health. Therefore, testing for WEE was not deemed necessary, but the North Dakota Public Health Laboratory maintains testing capability in the event of an outbreak.

Arbovirus Testing

2003 Eastern Equine Encephalitis

Background

Eastern Equine encephalitis is found along the Atlantic and Gulf Coasts and inland in limited areas of New York and the Midwest. Annually, there are a small number of cases nationwide; however, large localized outbreaks occurred in 1956, 1959, 1968, 1982 and 1983 (15).

Eastern Equine encephalitis is the most deadly of the North American mosquito-borne viruses. Like WEE, EEE cases are concentrated primarily in the young. The fatality rate among humans is 50 to 75% with most survivors having severe central nervous system dysfunction. EEE is extremely deadly in equines, with a mortality rate higher than 90% (15).

Results

2003 results are pending for mosquito pools tested for EEE.

Eastern Equine encephalitis was not considered a major agricultural or public health threat in North Dakota during 2003 by the Centers for Disease Control and Prevention and the North Dakota Department of Health. Therefore, testing for EEE was not deemed necessary, but the North Dakota Public Health Laboratory maintains testing capability in the event of an outbreak.

Arbovirus Testing

2003 St. Louis Encephalitis

Background
St. Louis encephalitis received its name from the St. Louis, Missouri, area where it was first recognized in 1933. Since 1933, SLE has been reported in 46 states. The largest outbreak of SLE occurred in 1975 when 1,815 cases were reported in 30 states, with a majority of the cases occurring in the Ohio and Mississippi valleys. There was another outbreak in Florida in 1990, in which 226 cases were reported (15).

St. Louis encephalitis is considered to be a more serious disease than WEE, but less so than EEE. Unlike WEE and EEE, SLE is more concentrated and severe in the elderly population. Most infections of SLE do not result in illness, with mild cases exhibiting aseptic meningitis or fever. However, in the more severe cases, fatality rates range from 2% to 20% with neurologic dysfunction occurring in a small percentage of survivors (15).

Results
2003 results are pending for mosquito pools tested for SLE.

St. Louis encephalitis was not considered a major agricultural or public health threat in North Dakota during 2003 by the Centers for Disease Control and Prevention and the North Dakota Department of Health. Therefore, testing for SLE was not deemed necessary, but the North Dakota Public Health Laboratory maintains testing capability in the event of an outbreak.

Arbovirus Testing

2003 California Serogroup Viruses

Background
The California serogroup are a group of several related viruses that included California encephalitis, La Crosse encephalitis, and Jamestown Canyon virus. Illness and/or mortality from these viruses have been reported primarily in states bordering or east of the Mississippi River, as well as Oklahoma, Texas and California. Occurring more often than EEE and WEE infections, about 75 cases are reported in the United Stated annually, with the vast majority of the illnesses resulting from La Crosse encephalitis (15).

The California serogroup viruses primarily infect children younger than 16 , and more often infects males than females. Infections are much less severe than most mosquito-borne illnesses, with a mortality rate of about four deaths per 1,000 infections (15).

Results
2003 results are pending for mosquito pools tested for California serogroup viruses.

The California serogroup virus encephalitides were not considered a major agricultural or public health threat in North Dakota during 2003 by the Centers for Disease Control and Prevention and the North Dakota Department of Health. Therefore, testing for California serogroup virus encephalitides was not deemed necessary, but the North Dakota Public Health Laboratory maintains testing capability in the event of an outbreak.

VecTest Study

Introduction

Recent technological advances enabled mosquito samples to be rapidly tested for arboviruses. The VecTest™ (Medical Analysis Systems, Inc, Camarillo, California) is a rapid immunochromatographic assay capable of qualitative detection of disease-causing pathogens directly from arthropod vectors (14).

For the VecTest™ procedure, mosquito pools are created containing from one to 50 mosquitoes. The pools are then ground and centrifuged. A 250µl aliquot of supernatant is removed from the vortexed mosquito homogenate and placed in a microcentrifuge tube. A test strip is inserted in the microcentrifuge tube for a period of 15 minutes.

The VecTest™ procedure requires no sample temperature restrictions and can be completed in 30 minutes. However, the test is not an amplification procedure; thus, unless the mosquito (or mosquitoes) carry sufficient viral loads, the test may produce a false negative.

In this study, all mosquito pools tested using the VecTest™ West Nile virus procedure were confirmed by the NASBA® procedure (14).

Results

A total of 96 *Culex tarsalis* mosquito pools were tested for the presence of WNV, nine were positive with the VecTest. In comparison, 11 tested positive for WNV using the NASBA procedure. The NASBA result was reported.

Table 3: NASBA® and VecTest™ Results for 2003

Location	County	Date	Date Tested		No. of	Mosquitoes	Trap	NASBA	VecTest
		Collected	VecTest	NASBA	Tested	Collected	#	Result	Result
Valley City	Barnes	7/15/2003	7/22/2003	7/29/2003	50	155	1	Positive	Negative
Jamestown	Stutsman	7/30/2003	8/6/2003	8/7/2003	50	89	1	Positive	Positive
Valley City	Barnes	7/30/2003	8/6/2003	8/7/2003	50	142	1	Positive	Positive
Williston	Williams	7/30/2003	8/6/2003	8/7/2003	14	14	2	Positive	Positive
Valley City	Barnes	8/7/2003	8/8/2003	8/8/2003	50	100	2	Positive	Positive
Williston	Williams	8/7/2003	8/8/2003	8/8/2003	50	73	2	Positive	Positive
Devils Lake	Ramsey	8/13/2003	8/25/2003	10/16/2003	50	121	1	Negative	Positive
Dickinson	Stark	8/13/2003	8/25/2003	10/16/2003	50	77	1	Negative	Positive
Bismarck	Burleigh	8/20/2003	8/25/2003	10/16/2003	15	15	1	Positive	Negative
Grand Forks	Grand Forks	8/20/2003	8/25/2003	10/16/2003	26	26	1	Positive	Negative
Grand Forks	Grand Forks	8/27/2003	9/15/2003	10/16/2003	27	27	1	Positive	Positive
Valley City	Barnes	8/27/2003	9/15/2003	10/17/2003	13	13	1	Positive	Negative
Valley City	Barnes	8/27/2003	9/15/2003	10/17/2003	42	42	2	Positive	Positive

Discussion

When compared to the NASBA® procedure, the VecTest™ procedure had an accuracy of 94%, a sensitivity of 68% and a specificity of 8%. Factors contributing to the low sensitivity and specificity include, but are not limited to (1) insufficient viral load; (2) cross reactivity with other flaviviruse; and (3) presence of environmental inhibitors.

Conclusion

This study was conducted over a short period of time, July through September 2003, testing one species of mosquitoes, *Culex tarsalis.* Further research is suggested using a longer period of time and expanded sampling to determine the value of this testing procedure in the NDDoH mosquito surveillance program.

North Dakota Mosquito Surveillance
Risk Assessment Chart
for Arbovirus Activity

Risk Category	Probability of human outbreak	Definition of Conditions	Recommended Response by Mosquito Surveillance Team and ND Vector Control Personnel
1a	Remote	Mid-season; first week of July; no observed epizootic activity; low population counts of vector species from New Jersey Trap Network.	Begin preliminary low intensity CDC live-trapping network and testing in all areas of the state; test for targeted virus presence.
1b		Late-season; third week of July through September; no observed epizootic activity; high population counts from New Jersey Trap Network.	Deploy mid-intensity CDC live-trapping network and viral testing in areas with high population counts of targeted vector species; continue low intensity trapping and testing in other areas.
2	Low	Sporadic epizootic activity in birds or mosquitoes.	Deploy high intensity CDC live-trapping network and viral testing in epizootic areas and consider preliminary control measures such as source reduction and larval control; continue surveillance in other areas.
3	Moderate	Initial confirmation of virus in horse or human; moderate activity in birds or mosquitoes.	Continue as in Category 2; consider adult mosquito control as indicated by surveillance activity.
4	High	Measures suggesting high risk of human infection (for example, high dead bird densities, high mosquito infection rates, multiple positive mosquito species, horse or mammal cases indicating escalating epizootic transmission, or a human case).	Response as in Category 3; initiate adult mosquito control program in areas of potential human risk.
5	Outbreak in progress	Multiple confirmed human cases; conditions as listed in Category 4.	Implement emergency adult mosquito control program; if widespread, consider aerial spraying.

2004 Mosquito Surveillance Program Recommendations

Recommendations from the 2002 North Dakota Mosquito Surveillance Program implemented in 2003:

1. All 53 North Dakota counties, 13 state parks, and four reservations had the opportunity to be represented by mosquito traps. With a weekly average of 80% trap operator participation, uniform surveillance across the state was achieved.
2. Training and pamphlets were provided in an effort to reduce sampling variation, specifically variation of trap locations. Random traps were inspected, with about 30% properly placed. This low percentage may be due to the location of the power source needed to run a New Jersey Mosquito Trap.
3. A total of 70 of the 87 trap sites across the state were operated by personnel associated with federal, state, county or city organizations, reducing the reliance on trap volunteers alone.

Recommendations for the 2004 program:

1. Continuation of a full-time Mosquito Surveillance Program coordinator, responsible for the coordination of mosquito trapping efforts, issuing trapping supplies, trap placement and speciation training, composition of the Mosquito Surveillance Program's annual report, and mosquito sample speciation.
2. Three full-time mosquito analysts to assist the Mosquito Surveillance Program coordinator in the speciation of mosquitoes, issuing of supplies, and completion of the Mosquito Surveillance Program's annual report. These positions would run from approximately May 1 to the end of September.
3. Address reducing sporadic contribution of samples by identifying and replacing those operators who did not participate during the 2003 surveillance season.
4. Continue working with local field epidemiologists to acquire GPS/GIS data for New Jersey Mosquito Trap and CDC Miniature Light Mosquito Trap sites throughout the state.
5. Prepare an instructional packet for submitting samples containing (1) a memo stating contents; (2) an instructional video depicting proper trap placement and collection procedures; (3) a labeled bag (location or city and collection date); and (4) a mailer labeled on the inside with contact and location information.
6. Prepare an organized deactivation plan in the event Mosquito Surveillance Program activities are ceased. Include in the plan a procedure for the return and storage of the New Jersey and CDC Mosquito Traps and accessories.

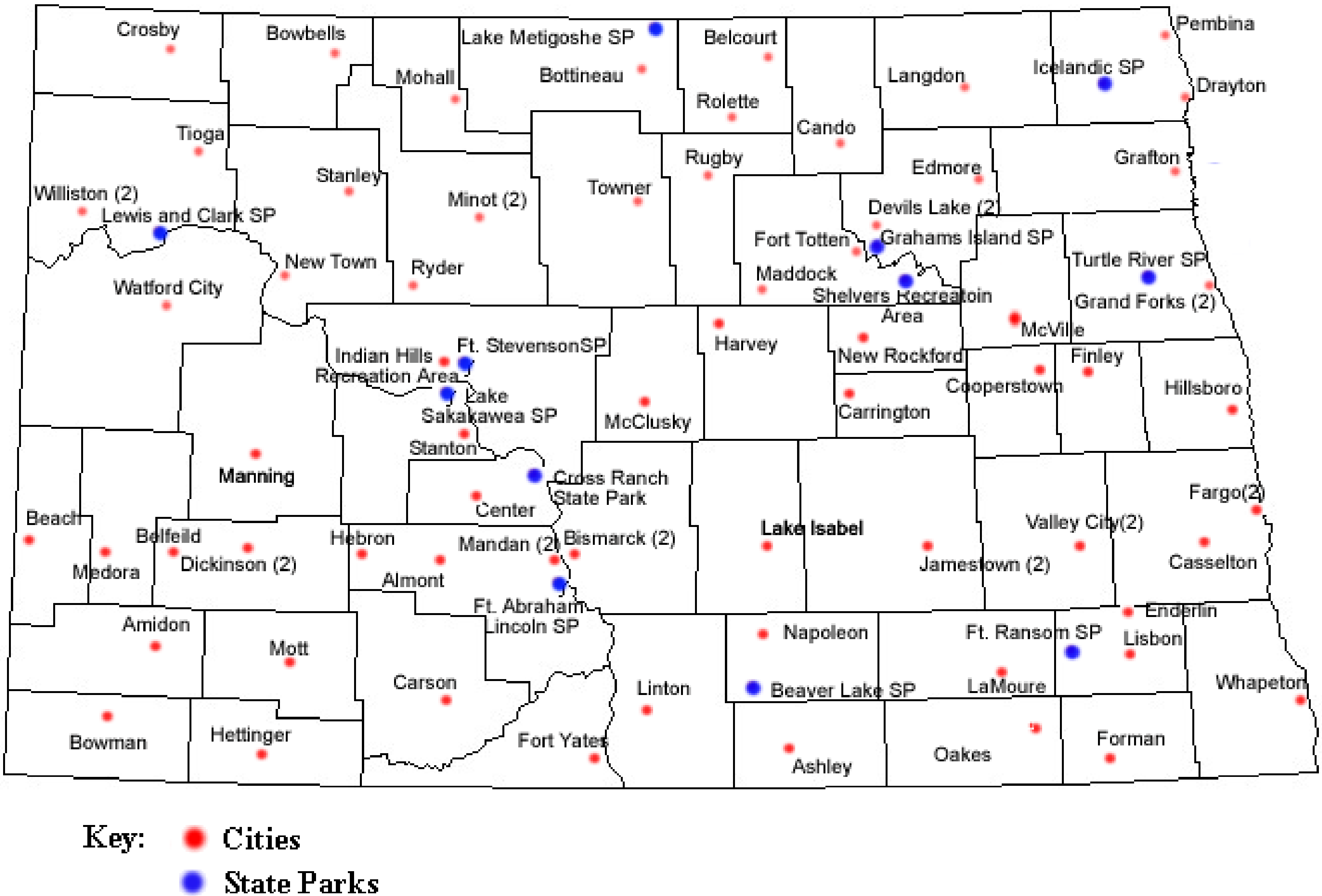
Appendix A Figures and Maps

(Figure 1)

(Figure 2)

(Figure 3)

2003 Mosquito Surveillance Trap Sites



(Figure 4)

Monitoring mosquito populations in relation to temperature and rainfall is fundamental to mosquito surveillance. Over time, information about how mosquito populations are influenced by changing seasonal dynamics may assist in the prediction of mosquito activity and thus arbovirus activity throughout a given area. The 2003 North Dakota Mosquito Surveillance Program, in addition to surveying mosquito populations and testing for West Nile virus, obtained information to compile regional graphs depicting the relationship between mosquito populations, temperature and rainfall accumulations. With this in mind, thorough knowledge of the mosquito life cycle, habitat and development factors will aid in the interpretation of the following data and graphs.

The mosquito life cycle has four distinct stages consisting of egg, larva, pupa and adult. A female mosquito breeds in the presence of water and lays fertile eggs after obtaining a blood meal. The location in which a female mosquito deposits her eggs in the environment depends upon larval habitat preference (15). The 36 mosquito species indigenous to North Dakota can be grouped into four categories that reflect their larval habitat preference. These categories include the permanent pool group, the transient water group, the floodwater group, and the artificial container and tree-hole group (11, 15).

Mosquitoes within the permanent pool group lay eggs either singly or side by side on the water surface of permanent ponds and lakes. Mosquitoes included in the permanent pool group are primarily of the genus *Anopheles,* along with a few selected *Culex* species.

The egg-laying habits of a transient water mosquito like the *Culex tarsalis* are similar to the permanent pool group, except these mosquitoes prefer to lay their eggs in pools of a temporary nature. Common habitats of the transient water group are roadside ditches, borrow pits, canals, ground pools and irrigated lands.

Most species of the genus *Aedes* including *Aedes vexans*, possibly the most numerous mosquito in North Dakota, are floodwater mosquitoes. Eggs are placed singly on damp soil or along vegetated shorelines and remain dormant until these areas are flooded. Once flooded, the eggs hatch if conditions are favorable. Large numbers of larvae emerge, and adults can appear as early as six days after flooding.

The artificial container and tree-hole group of mosquitoes place their eggs inside the wall of a container or depression inside a tree, at or above the water line, and the eggs hatch when the water levels rise (15).

Once hatched, larvae of all species emerge and live in water. After four stages, or instars, the larva molts into a pupa. The pupa stage is a resting, nonfeeding stage where the pupa is encased until the adult matures and emerges from the skin after one and a half to four days. Adult male mosquitoes, on average, live from six to seven days. Female mosquitoes, on the other hand, usually live for about two weeks but can live for up to five months with ample food. The longer female mosquito life span allows sufficient time for a virus such as WNV to mature within the mosquito. Once infected, a female mosquito may remain so for her lifetime, with the potential to transmit the virus to every susceptible host she feeds on. (15).

One should expect to find peak adult mosquito populations within a two-week time period after a batch of eggs hatches. Two factors that affect the numbers of mosquitoes that emerge and their rate of development into an adult are temperature and rainfall. Mosquito eggs require certain weather conditions to hatch. Permanent pool mosquitoes can develop continuously in warm water and hatch daily into adults. Transient water mosquito eggs in ditches and small depressions must wait until rainfall to begin the hatching process. A major rainstorm, a series of showers, or irrigation sufficient enough to produce standing water promotes hatching in the floodwater species of mosquitoes. A heavy rain resulting in standing water in normally dry margins of natural sites or old tires, tin cans, and flowerpots will begin the hatching process for artificial container mosquitoes (1).

Along with increased rainfall, warmer water temperatures speed up hatching and larval development. If outdoor temperatures are 50° F or more, productive breeding sites readily produce mosquito larvae. With increasing water temperatures, large mosquito populations can emerge within one week. Research in laboratory settings has shown that if the water temperature exceeds 100° F, it takes only three to four days for larval metamorphosis; if the temperature is 90° F, it takes five days; and a lower water temperature of 70° F decreases rate of growth to 10 days (1). Floodwater species of *Aedes* larvae generally metamorphose within five to seven days after hatching. The species *Culex tarsalis* completes its life cycle in 14 days at 70°F and in only 10 days at 80°F (15).

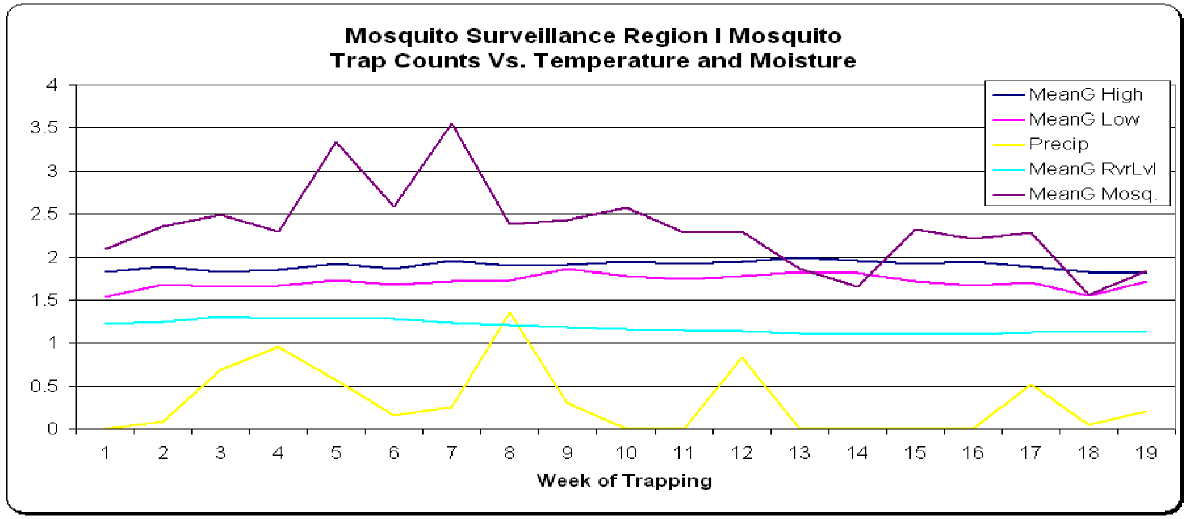
When a mosquito becomes an adult, the weather elements affect its peak activity. Most mosquitoes are active from dusk until dawn when wind speeds are less than eight miles per hour, the air temperature is between 65°F and 80° F, and the weather is moderate. Heavy rains, gusting winds, and cool or high daytime temperatures all limit a mosquito's feeding activity (1). At temperatures less than 50°F, mosquitoes become sluggish, reducing their host-seeking behavior. At higher temperatures, usually during daytime hours, adult mosquitoes seek cover in vegetated or humid areas with shade (3).

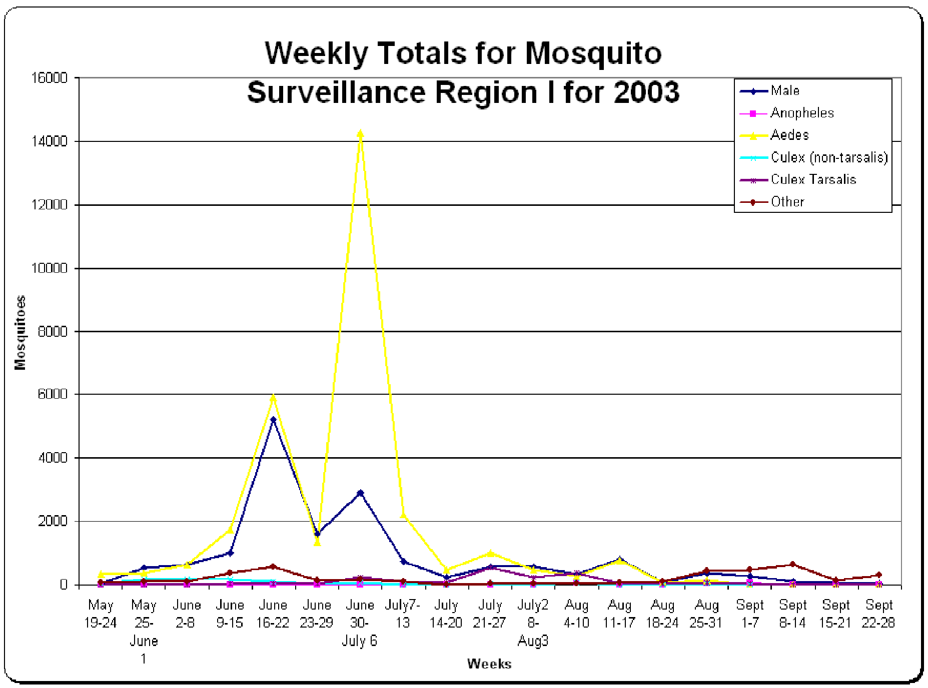
Mosquito populations are not uniformly distributed throughout a trapping area as a result of environmental and biological differences among trap sites. By taking the geometric mean, the environmental and biological differences that may skew the data are minimalized. In addition to minimalizing skewing, the geometric mean creates a direct proportional relationship, as well as changes the value to another scale, enabling practical data comparison. For these purposes the geometric mean was used in the creation of the following graphs.

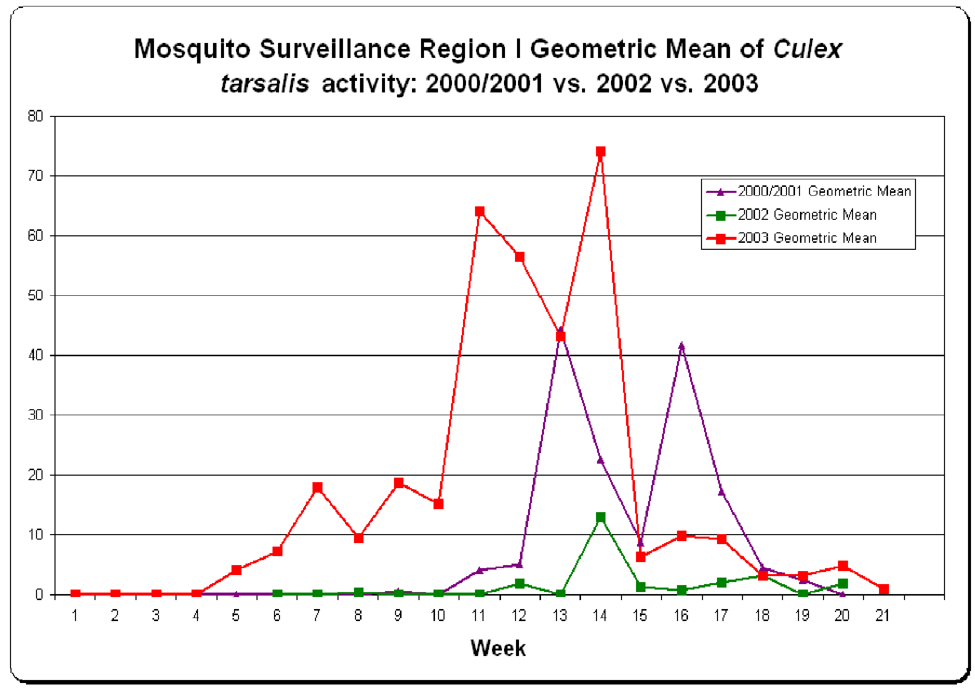
Mosquito Surveillance Region I 2003

Trapping Sites within Region I

- Crosby
- Lewis & Clark State Park
- New Town
- Stanley
- Tioga
- Watford City
- Williston #1
- Williston #2



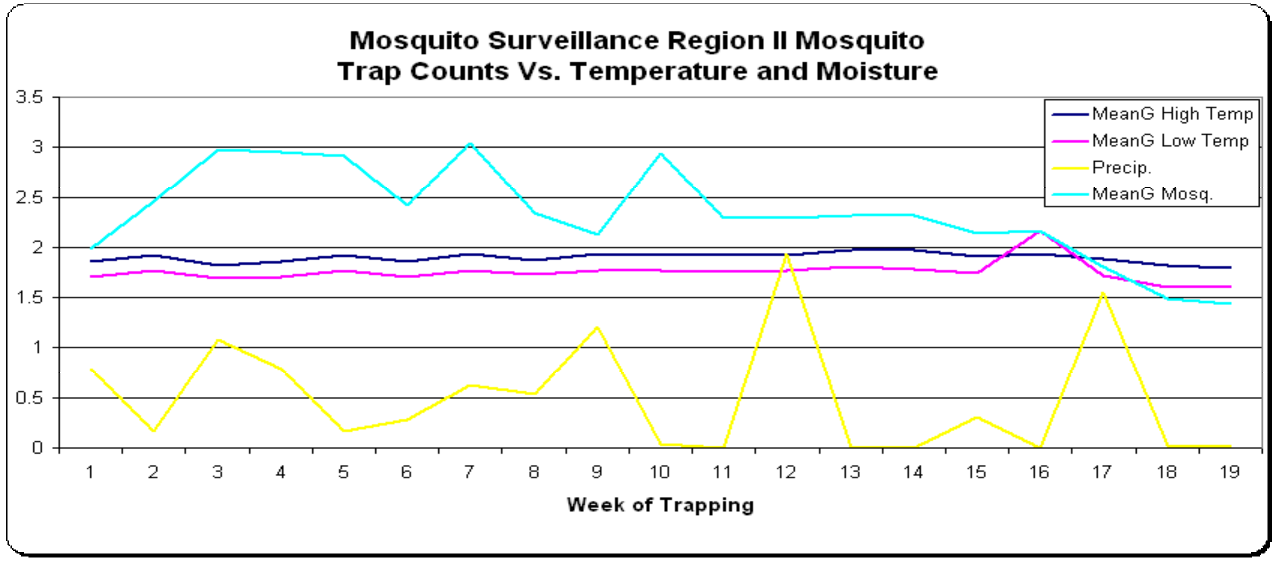


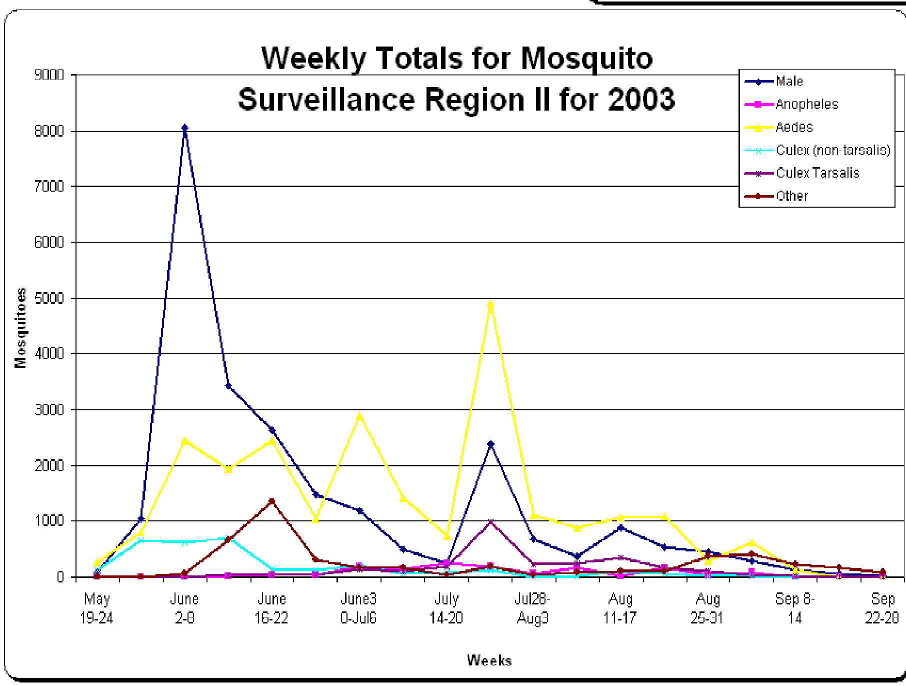


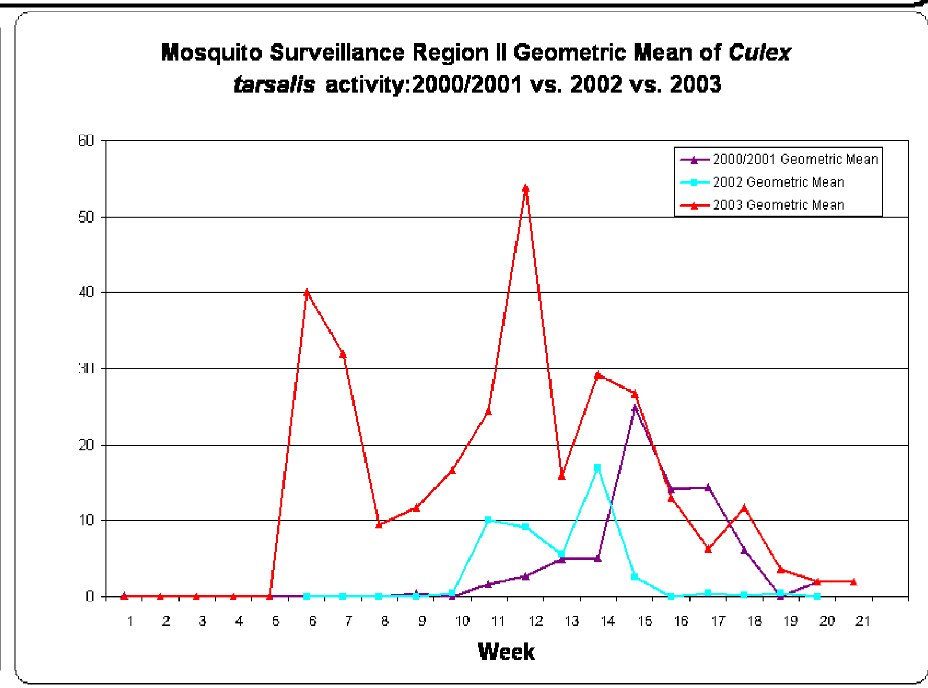
Mosquito Surveillance Region II 2003

Trapping Sites within Region II

Bottineau
Bowbells
Fort Stevenson
Indian Hills
Lake Metigoshe
McClusky
Minot #1
Minot #2
Renville County
Ryder
Towner



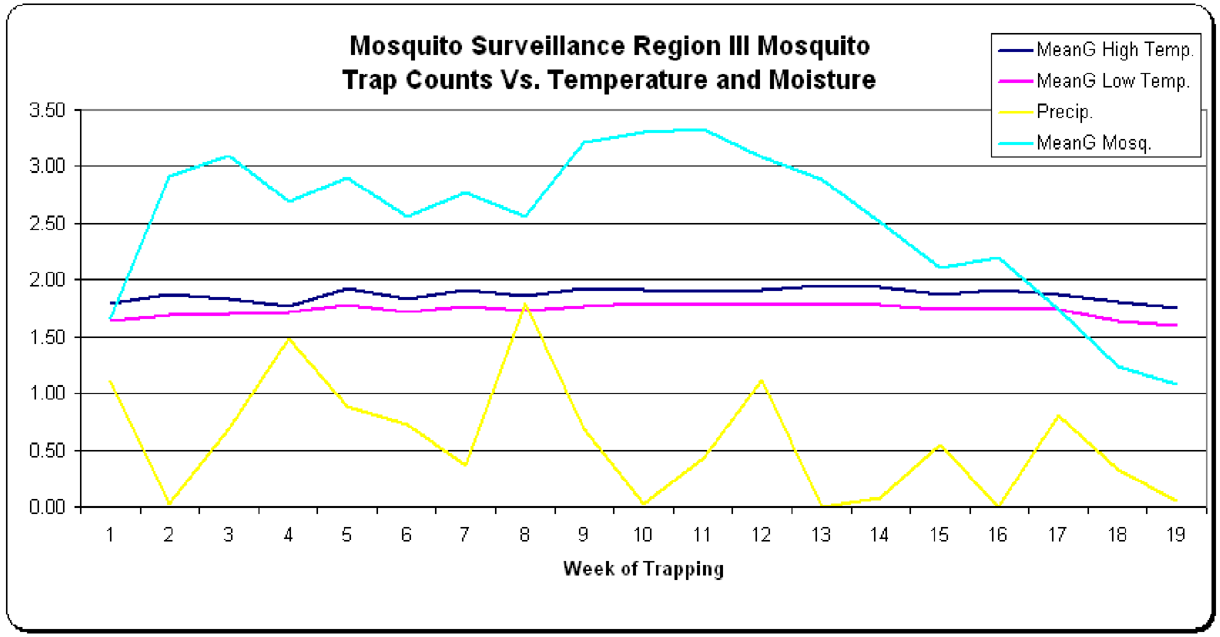


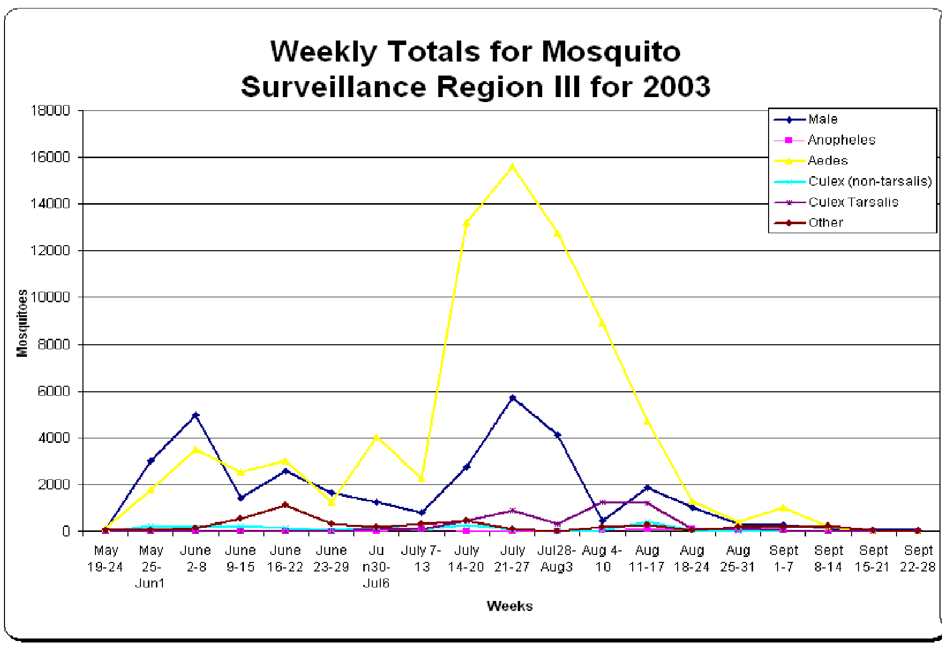


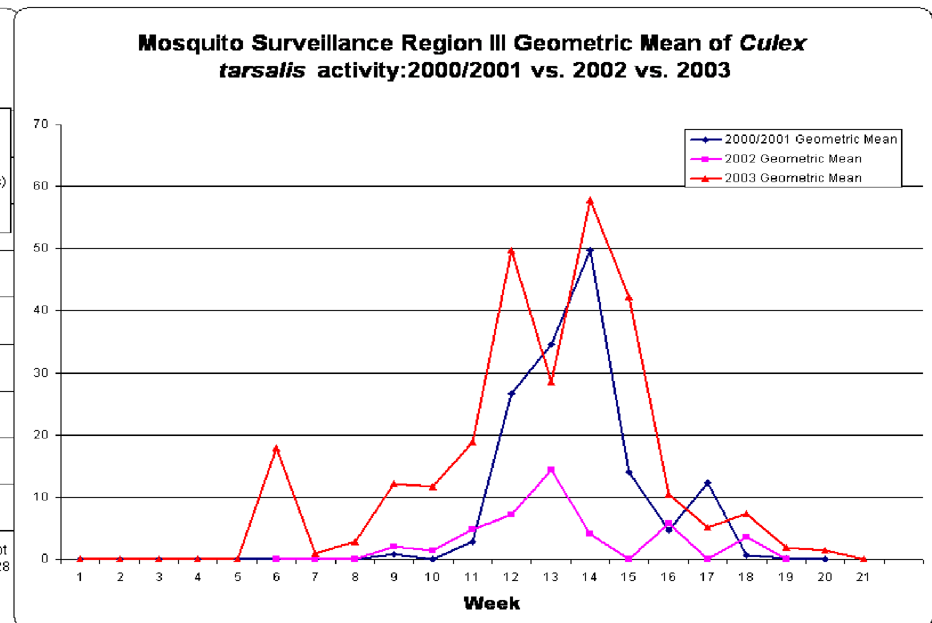
Mosqutio Surveillance Region III 2003

Trapping Sites within Region III

Belcourt
Devils Lake #1
Devils Lake #2
Edmore
Fort Totten
Grahams Island State Park
Langdon
Maddock
New Rockford
Rolette
Rugby
Shelvers State Park



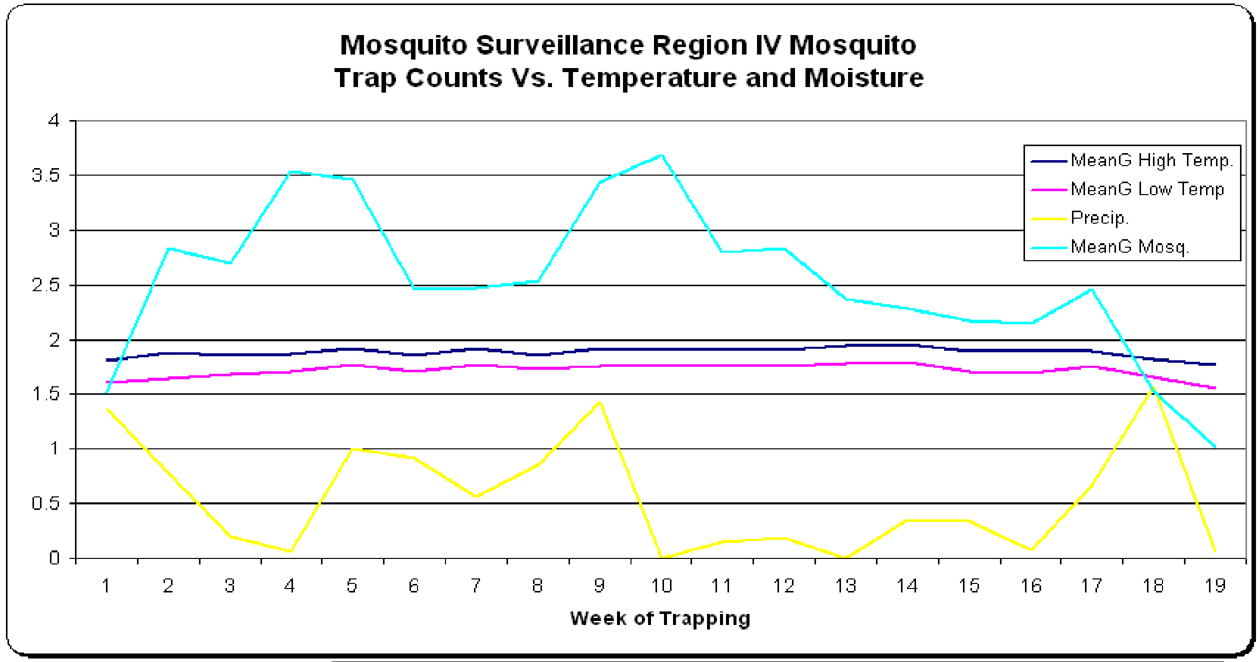


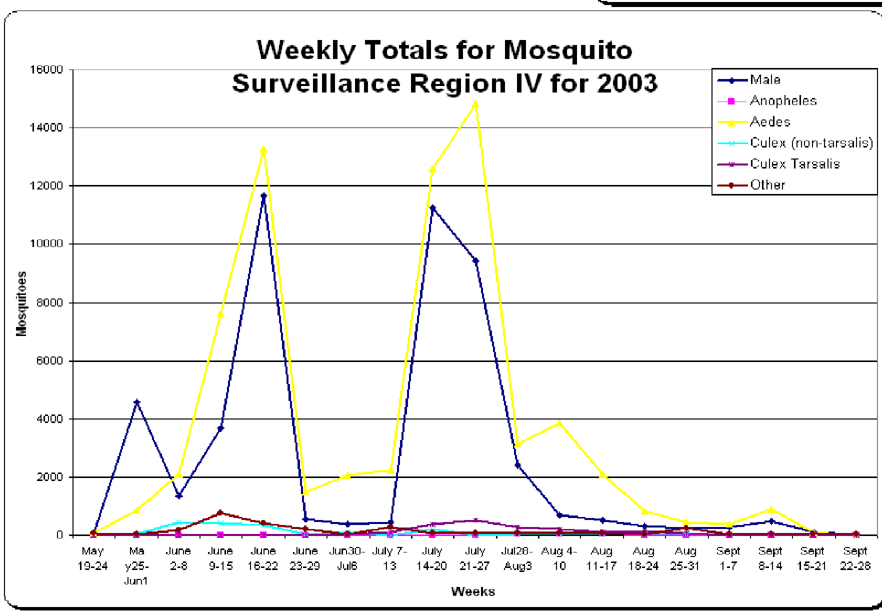


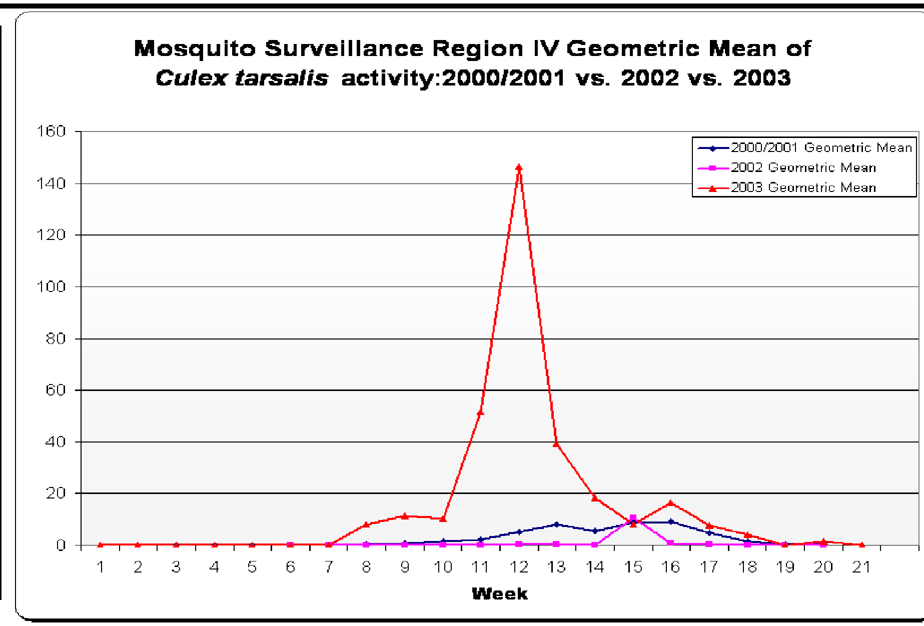
Mosquito Surveillance Region IV 2003

Trapping Sites within Region IV

Cooperstown
Drayton
Grafton
Grand Forks #1
Grand Forks #2
Icelandic State Park
McVille
Pembina
Turtle River State Park



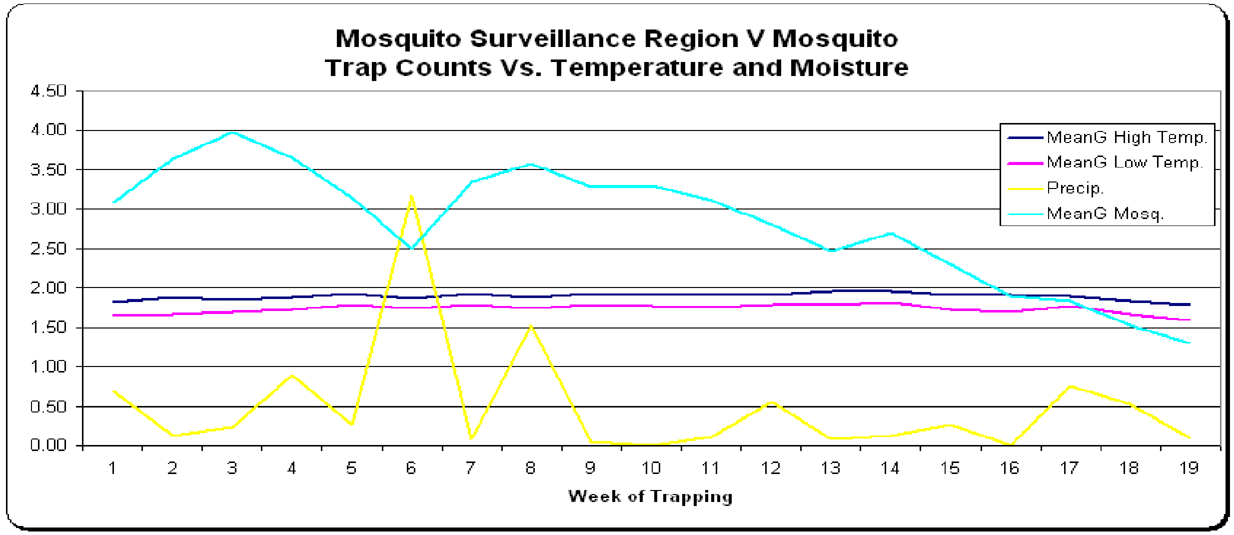


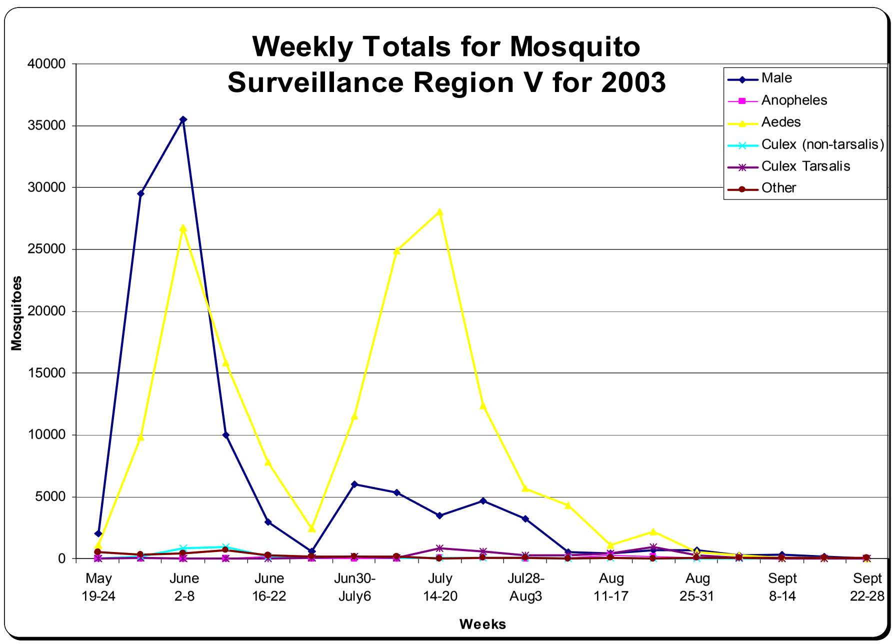


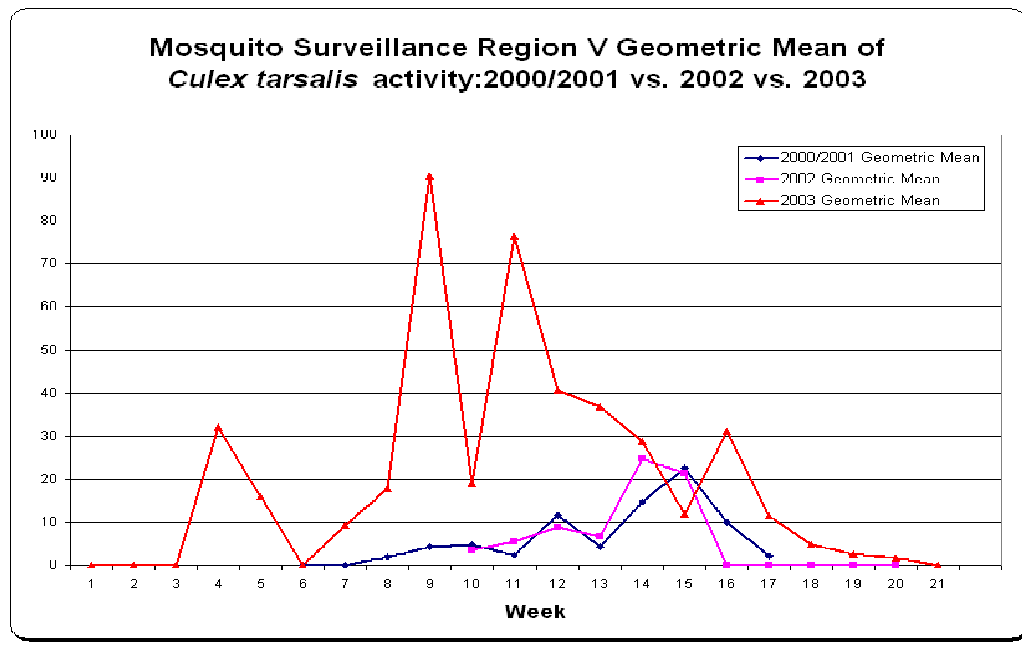
Mosquito Surveillance Region V 2003

Trapping Sites within Region V

Casselton
Enderlin
Fargo #1
Fargo #2
Finley
Forman
Fort Ransom State Park
Hillsboro
Lisbon
Wahpeton



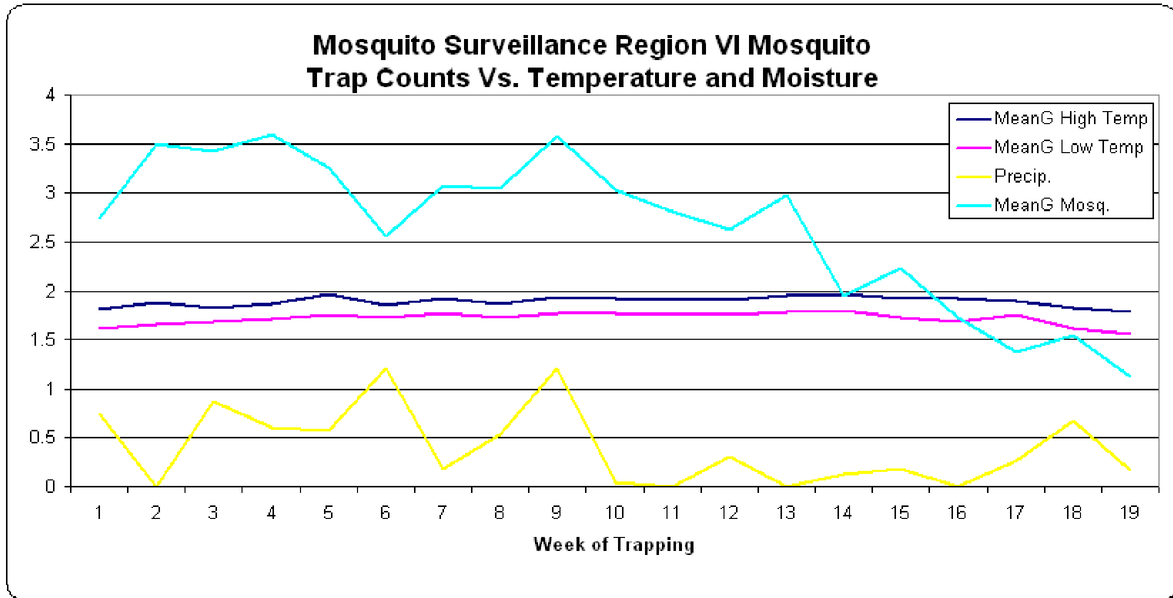


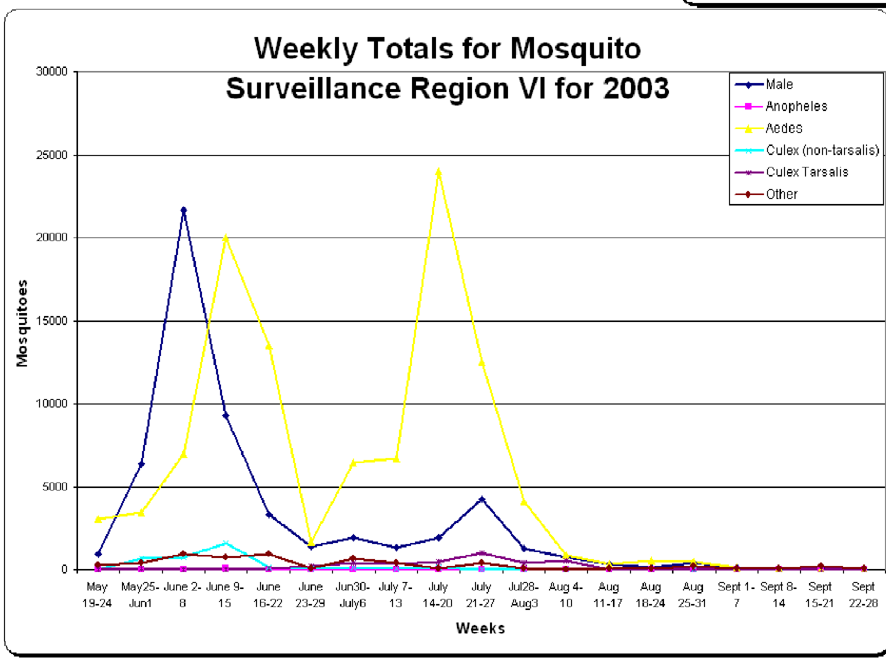


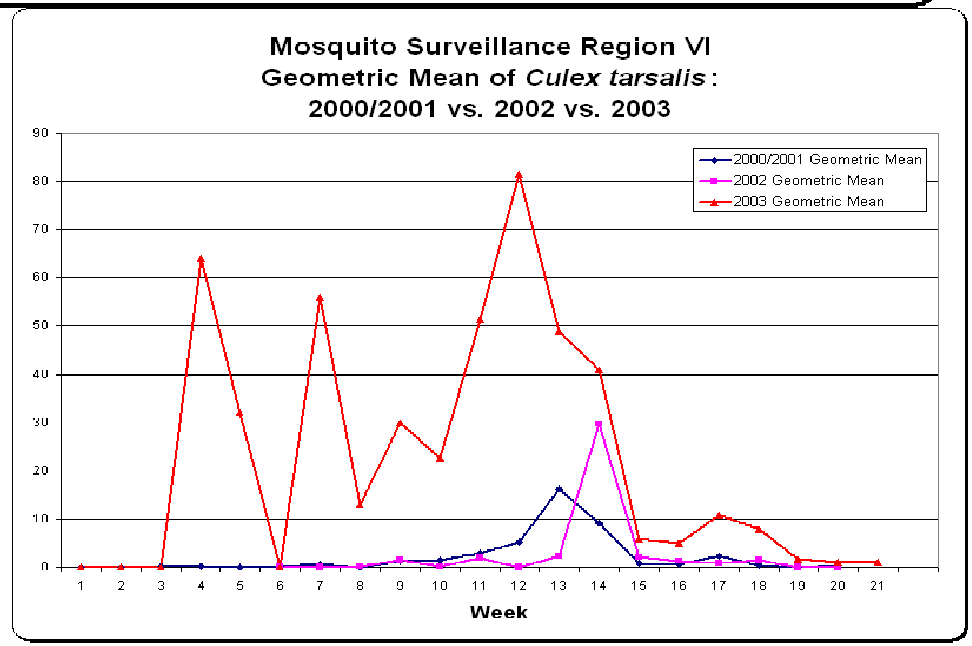
Mosquito Surveillance Region VI 2003

Trapping Sites within Region VI

Ashley
Beaver Lake State Park
Carrington
Harvey
Jamestown #1
Jamestown #2
LaMoure
Napoleon
Oakes
Valley City #1
Valley City #2



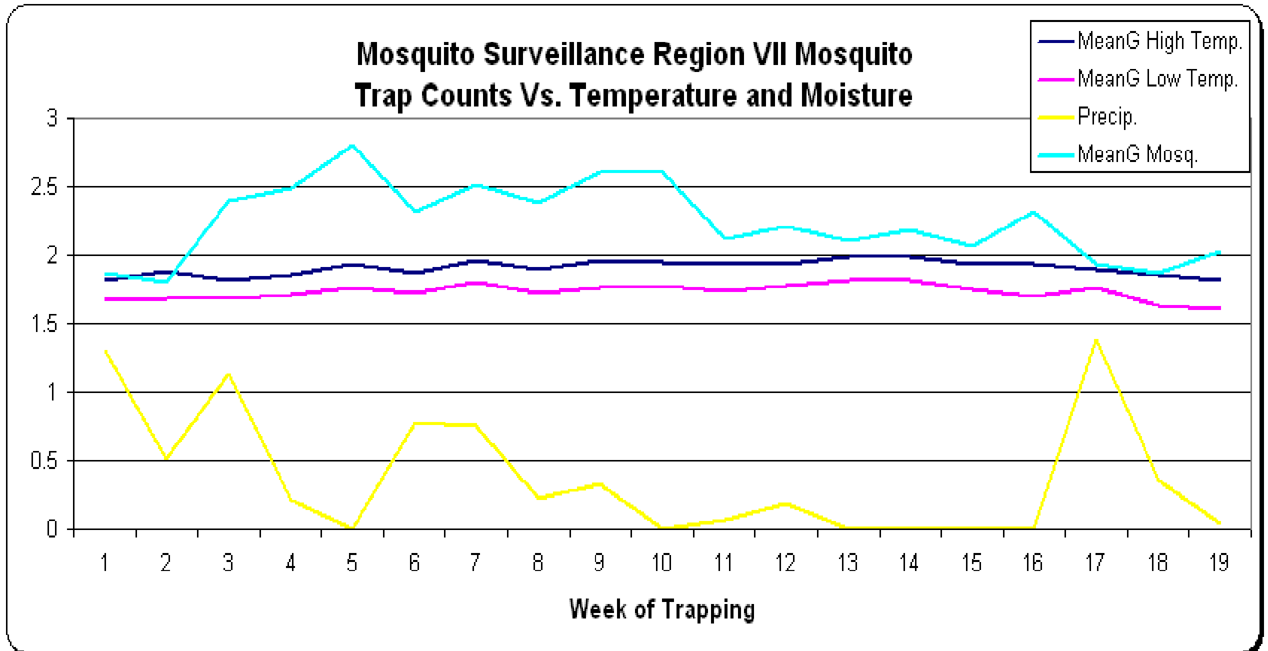


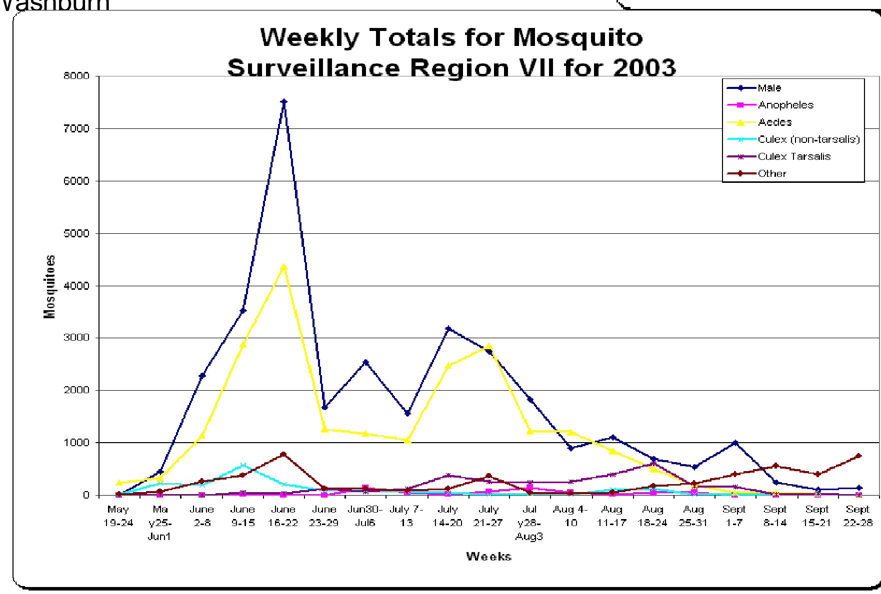


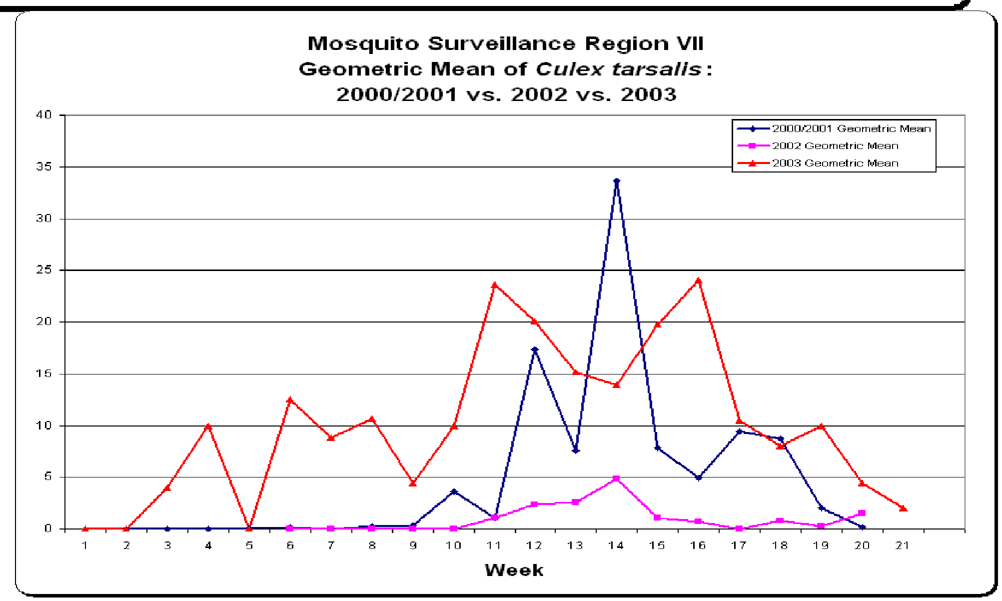
Mosquito Surveillance Region VII 2003

Trapping Sites within Region VII

Almont
Beulah
Bismarck #1
Bismarck #2
Carson
Center
Cross Ranch State Park
Fort Yates
Fort Abraham Lincoln State Park
Hazen
Hebron
Kidder County
Lake Sakakawea State Park
Linton
Mandan #1
Mandan #2
Washburn



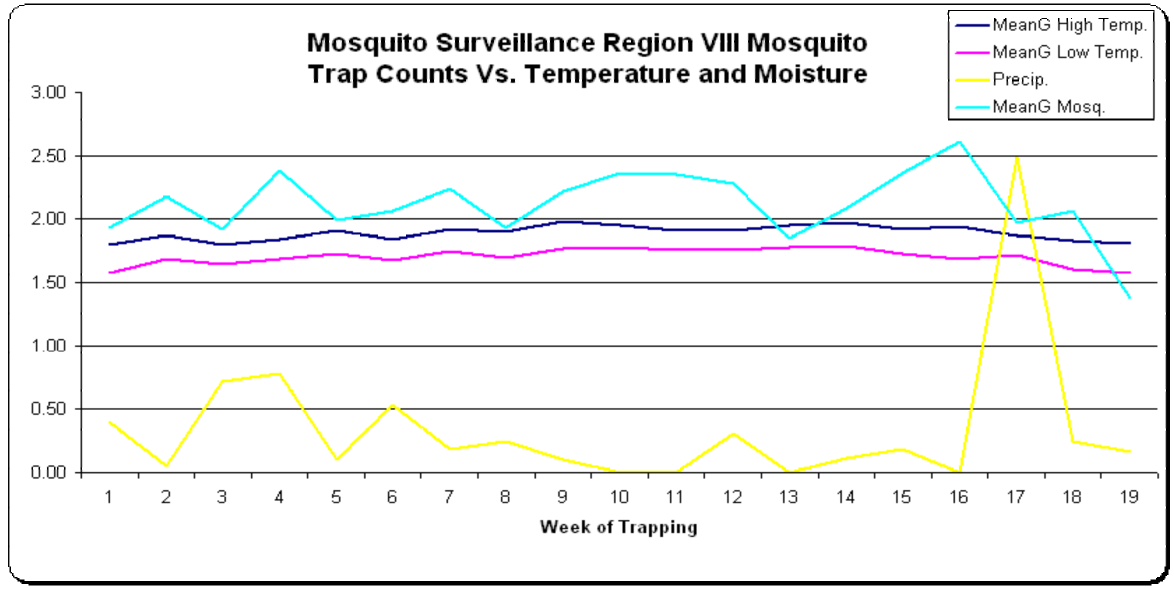


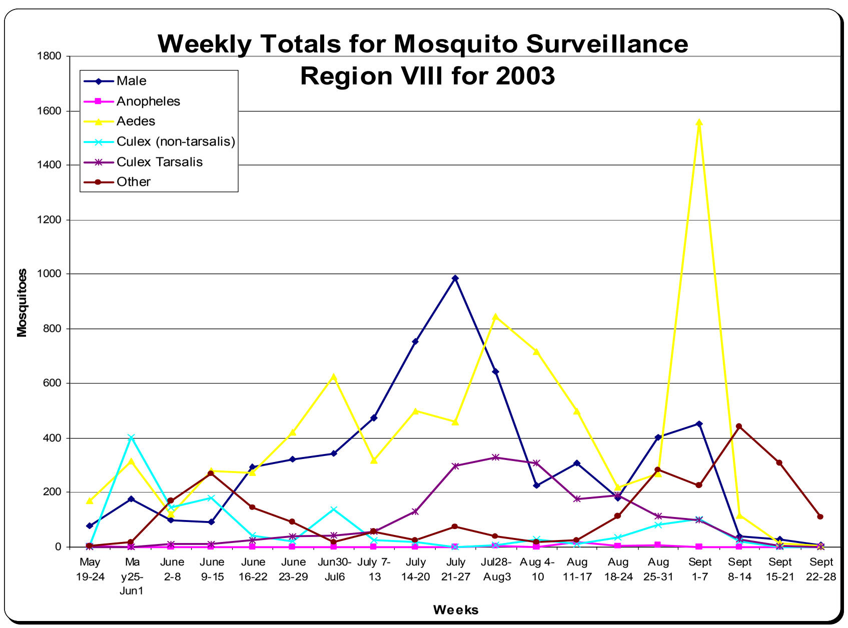


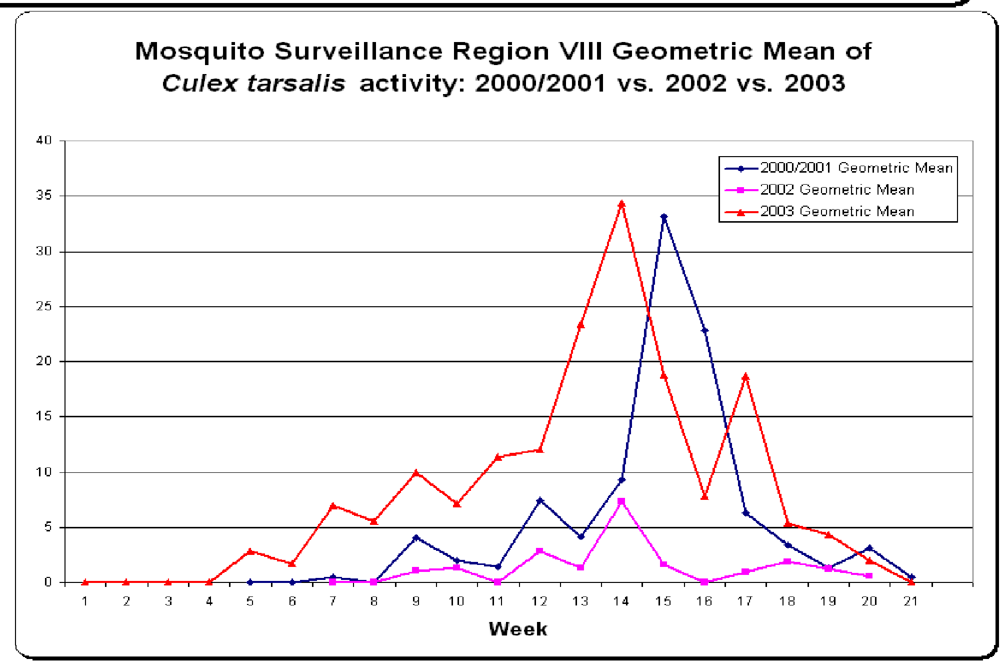
Mosquito Surveillance Region VIII 2003

Trapping Sites within Region VIII

Amidon
Beach
Belfield
Bowman
Dickinson #1
Dickinson #2
Dunn County
Hettinger
Medora
Mott







Appendix C includes graphs of trap counts from the last week of May through the first week of September. These graphs depict how the mosquito trap counts have changed throughout the years of 1994 through 2003.

The general trend of North Dakota's mosquito population is a steady rise in population peaking in early to late July, followed by a gradual decrease through the rest of the mosquito season. When 2003's data is compared to previous years, from 1994 to 2002, the general trend is easily seen. Yearly and weekly variances in trap numbers can be attributed to abiotic factors such as rainfall and temperature, as well as the number of sites in the state's New Jersey Mosquito Trap Network.

Mosquito populations are not uniformly distributed throughout a trapping area as a result of environmental and biological differences among trap sites. Therefore, using the geometric mean minimalizes the environmental and biological differences that may skew the data, creates a direct proportional relationship, and changes the value to another scale that enables practical data comparison. For these purposes the geometric mean was used in the creation of the following graphs.

Weekly Geometric Mean of Trap Counts from 1994-2003

First Week of May

Year	Mean G
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	287.98
2001	No Data
2002	No Data
2003	No Data

Second Week of May

Year	Mean G
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	58.95
2001	No Data
2002	No Data
2003	No Data

Third Week of May

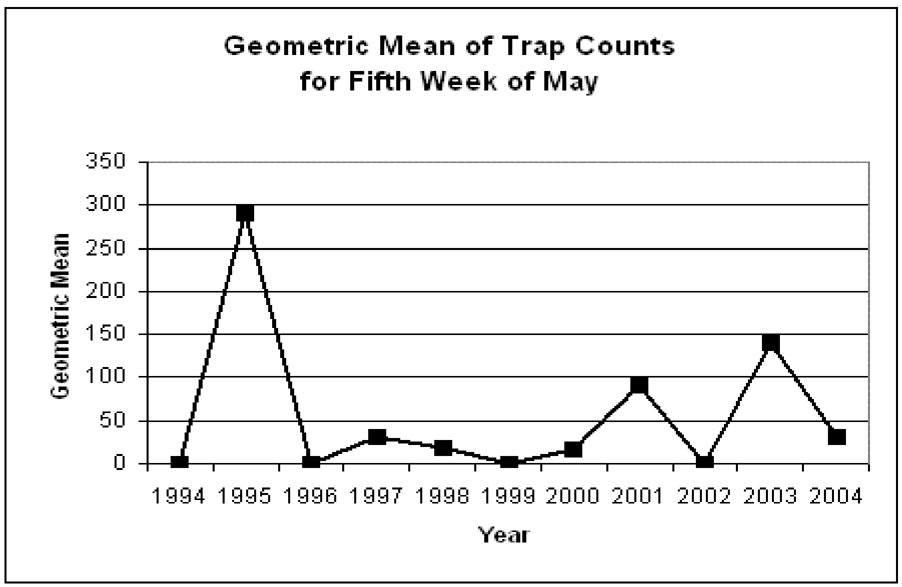
Year	Mean G
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	56.27
2001	No Data
2002	No Data
2003	No Data

Fourth Week of May

Year	Mean G
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	92.62
2001	64.03
2002	No Data
2003	No Data

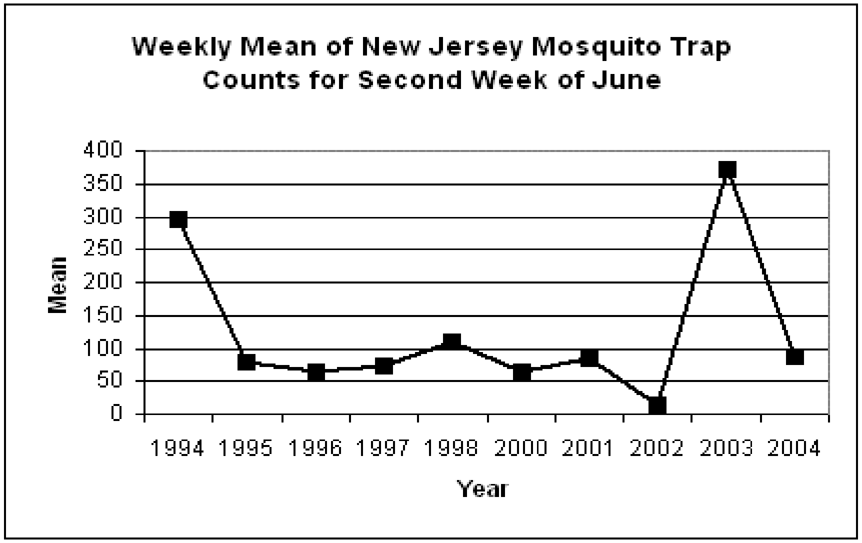
Fifth Week of May - First Week of June

Year	Mean
1994	No Data
1995	289.9
1996	No Data
1997	30.67
1998	18.6
1999	No Data
2000	15.71
2001	89.89
2002	No Data
2003	140.93



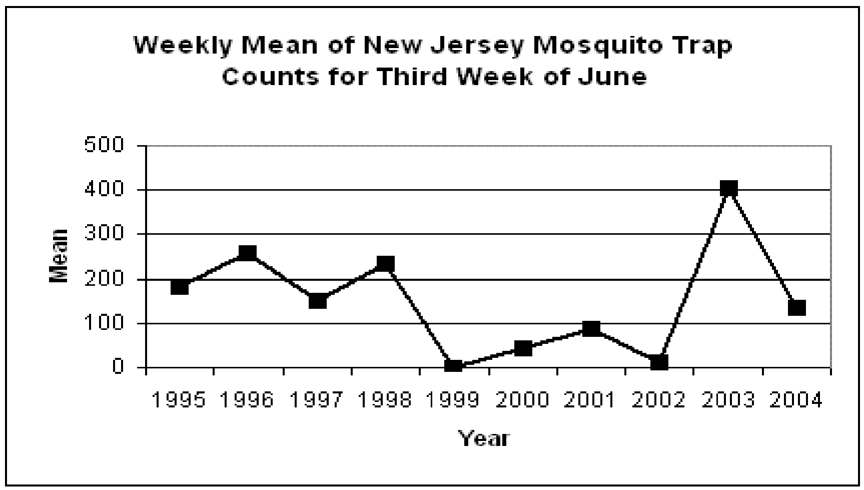
Second Week of June

Year	Mean G
1994	296.85
1995	78.56
1996	63.54
1997	72.04
1998	109.52
2000	66.06
2001	85.16
2002	15.21
2003	371.89
2004	87.57

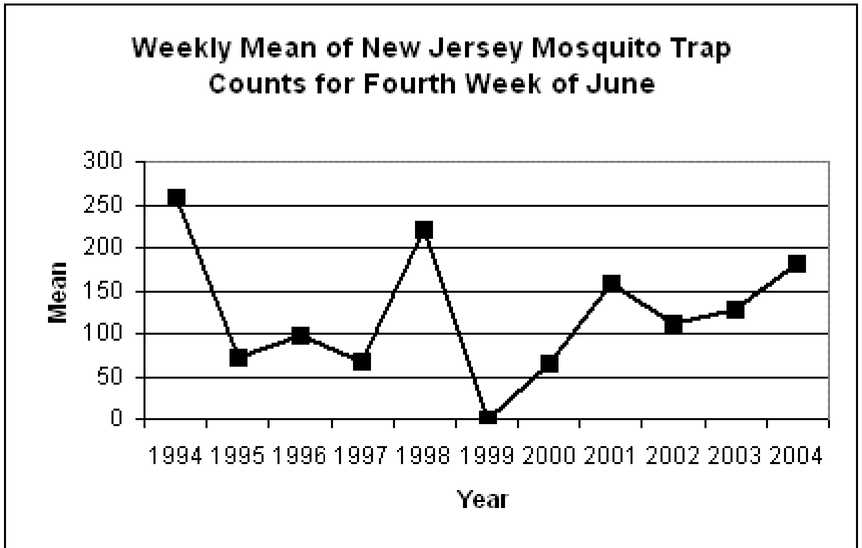


Third Week of June

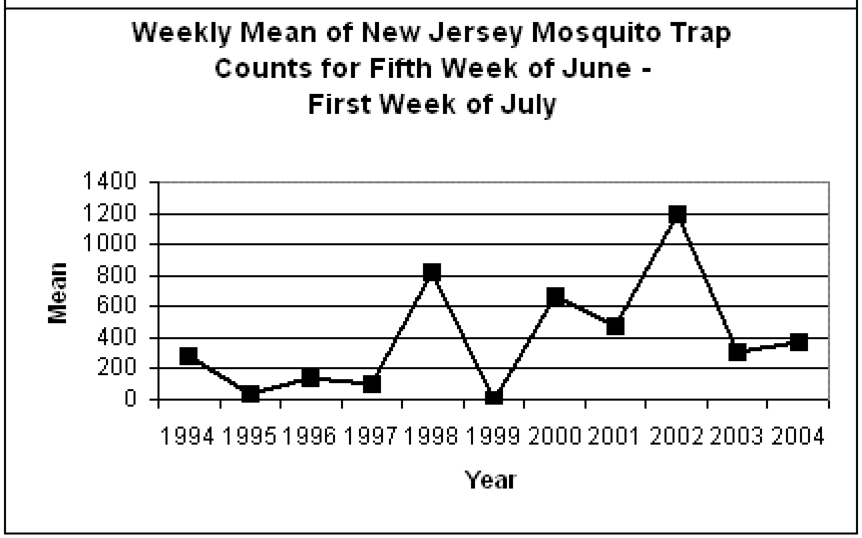
Year	Mean G
1994	No Data
1995	182.44
1996	257.27
1997	151.45
1998	234.59
1999	No Data
2000	43.93
2001	87.12
2002	12.71
2003	404.91
2004	133.04



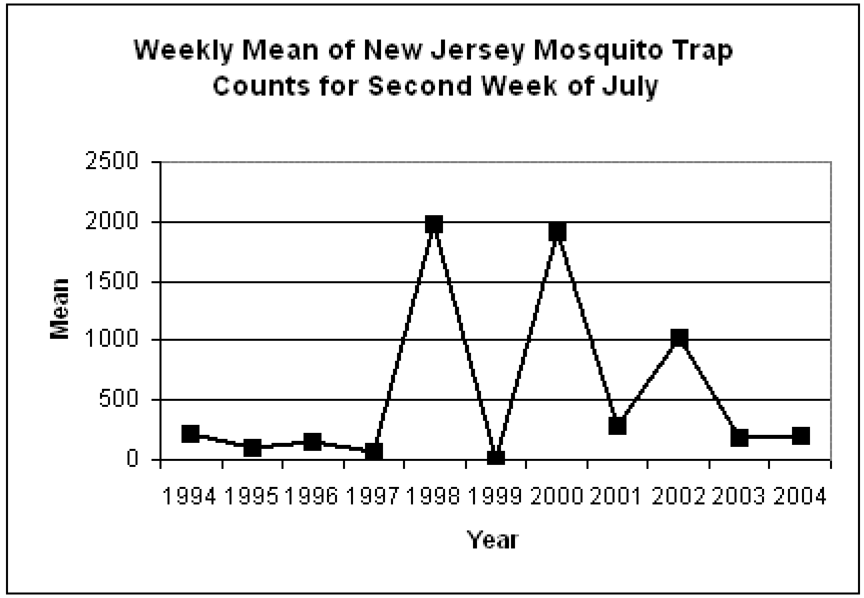
Fourth Week of June	
Year	Mean G
1994	259.04
1995	71.38
1996	97.47
1997	66.63
1998	220.93
1999	No Data
2000	64.58
2001	158.27
2002	111.74
2003	128.8
2004	180.73



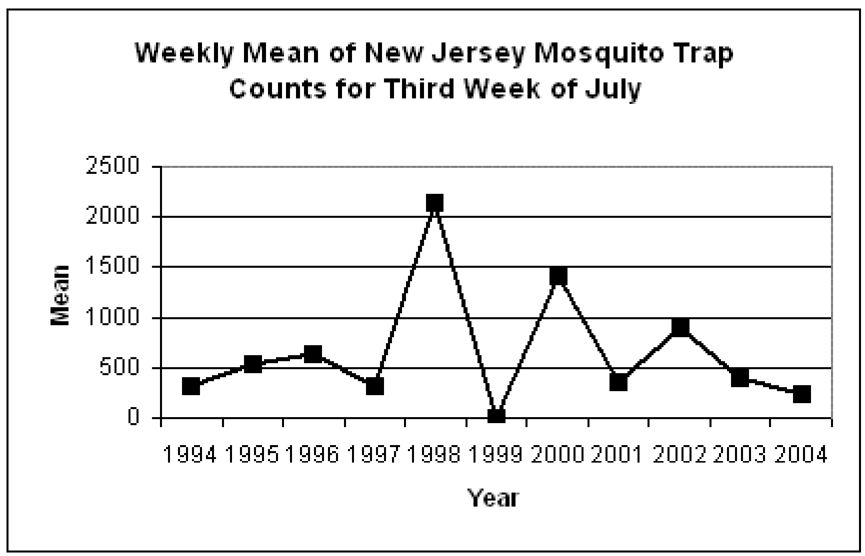
Fifth Week of June - First Week of July	
Year	Mean G
1994	277.1
1995	36.34
1996	135.37
1997	98.01
1998	819.68
1999	No Data
2000	673.77
2001	473.28
2002	1192.27
2003	308.65
2004	366.7



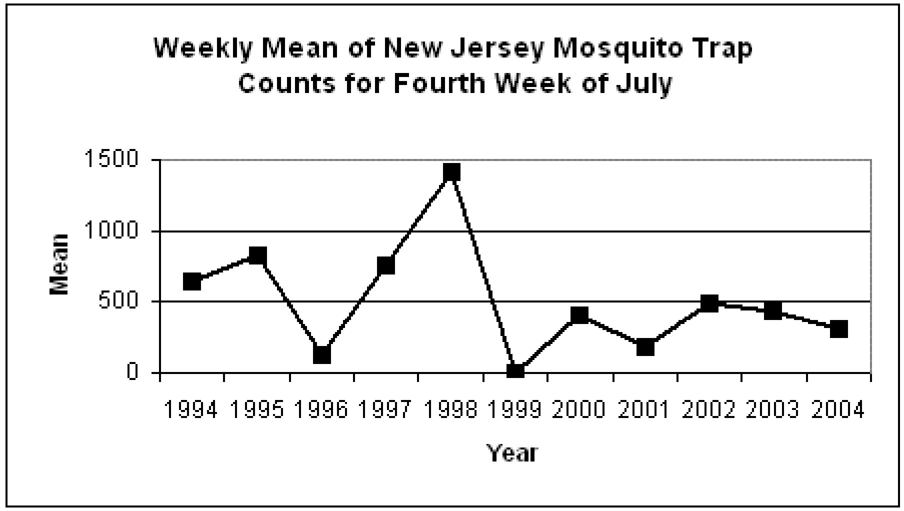
Second Week of July	
Year	Mean G
1994	211.2
1995	93.76
1996	156.6
1997	70.11
1998	1972.05
1999	No Data
2000	1913.94
2001	282.07
2002	1030.4
2003	178.5
2004	198.07



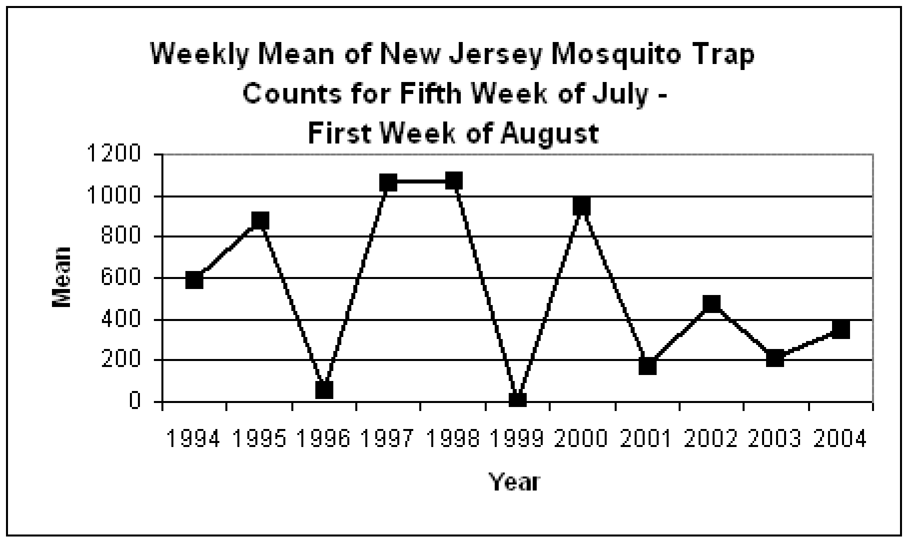
Third Week of July	
Year	Mean G
1994	310.7
1995	530.41
1996	633.42
1997	317.99
1998	2149.58
1999	No Data
2000	1399.34
2001	349.22
2002	902.75
2003	402.04
2004	241.25



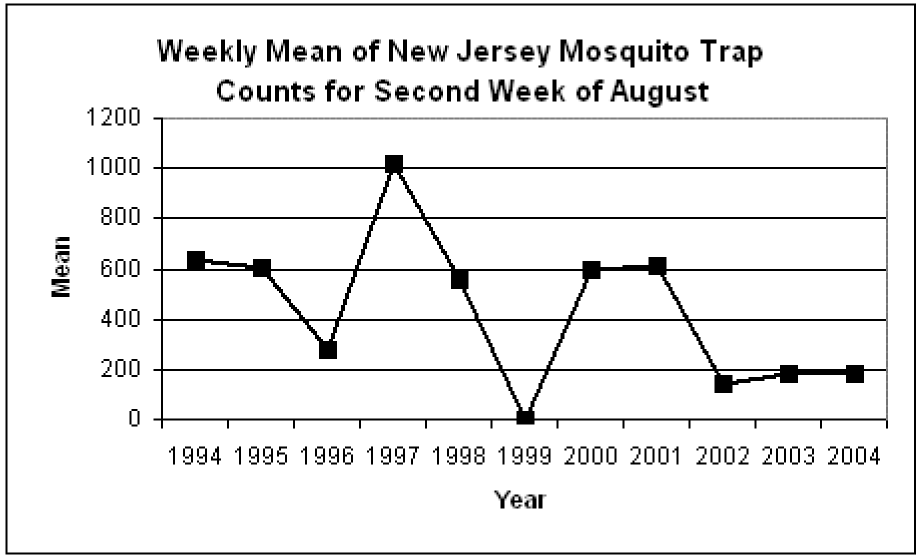
Fourth Week of July	
Year	Mean G
1994	642.29
1995	831.49
1996	131.87
1997	762.41
1998	1421.06
1999	No Data
2000	405.4
2001	180.42
2002	487.9
2003	435.11
2004	313.72



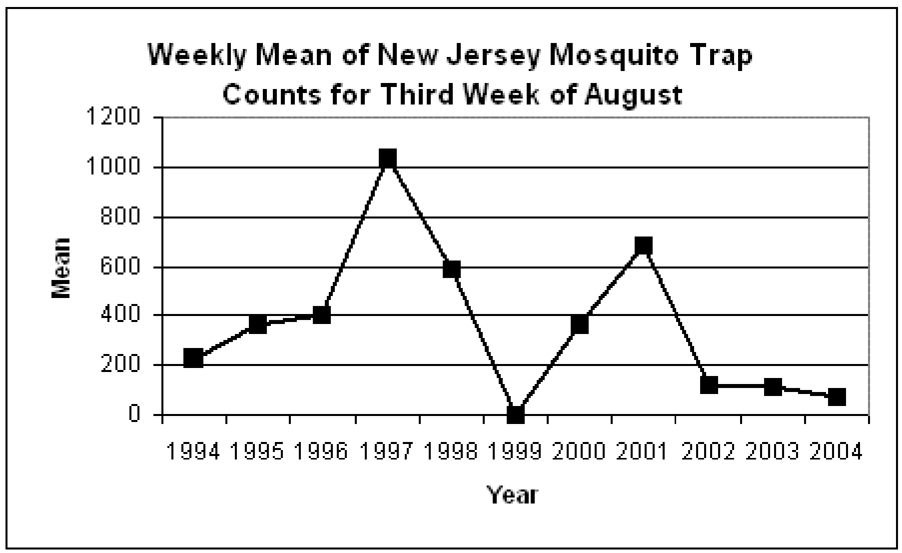
Fifth Week of July - First Week of August	
Year	Mean G
1994	585.66
1995	884.77
1996	56.15
1997	1067.04
1998	1077.32
1999	No Data
2000	951.76
2001	176.61
2002	475.13
2003	215.24
2004	346.85



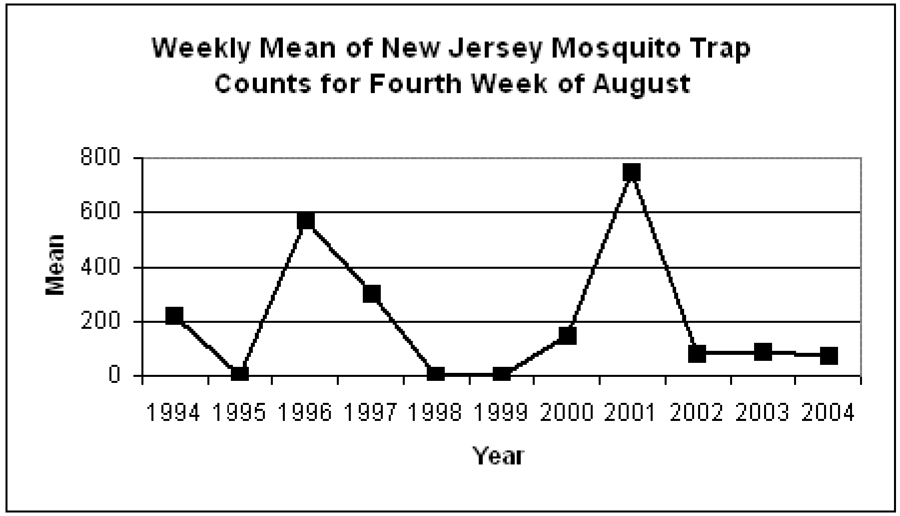
Second Week of August	
Year	Mean G
1994	634.72
1995	601.36
1996	278.54
1997	1020.82
1998	557.36
1999	No Data
2000	595.38
2001	613.8
2002	139.5
2003	182.78
2004	184.35



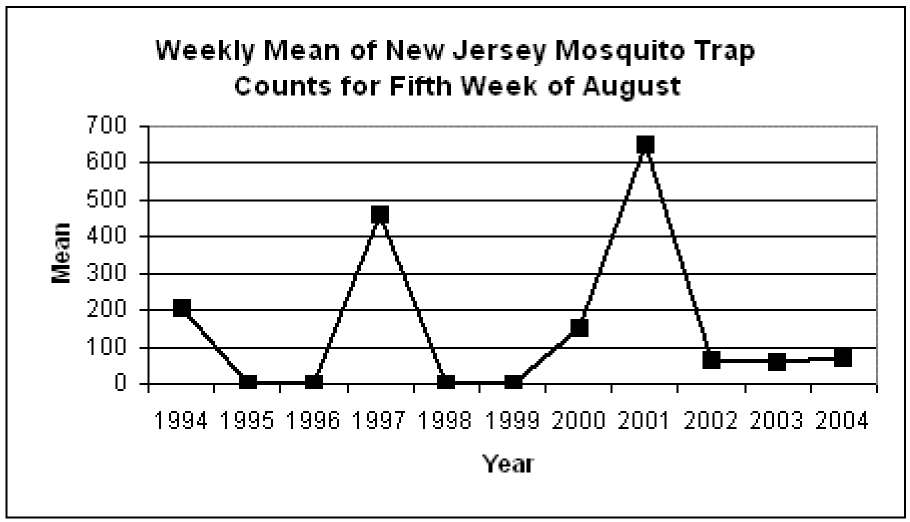
Third Week of August	
Year	Mean G
1994	222.49
1995	365.85
1996	406.12
1997	1036.56
1998	588.09
1999	No Data
2000	362.46
2001	686.53
2002	123.5
2003	110.62



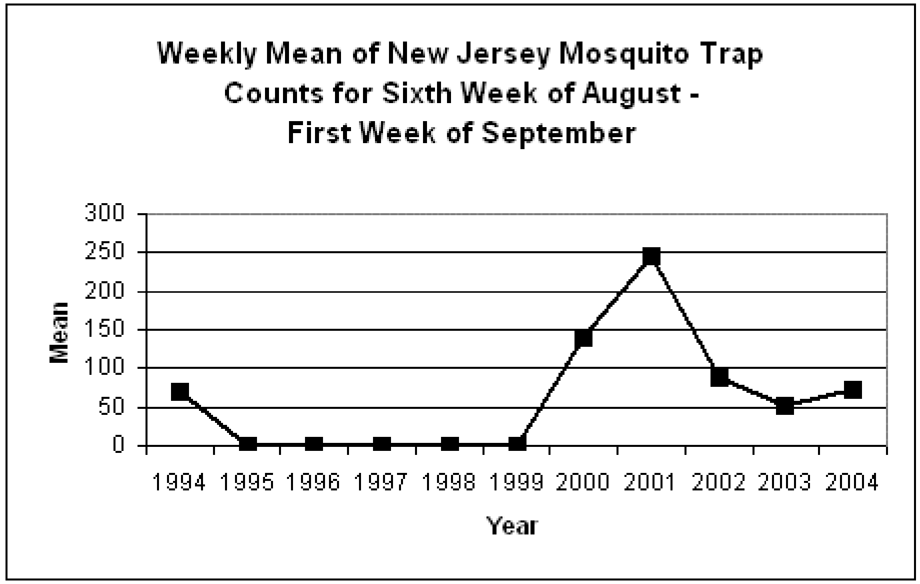
Fourth Week of Fourth Week of August	
Year	Mean G
1994	222.43
1995	No Data
1996	570.88
1997	301.75
1998	No Data
1999	No Data
2000	146.56
2001	750.53
2002	78.33
2003	88.18
2004	70.27



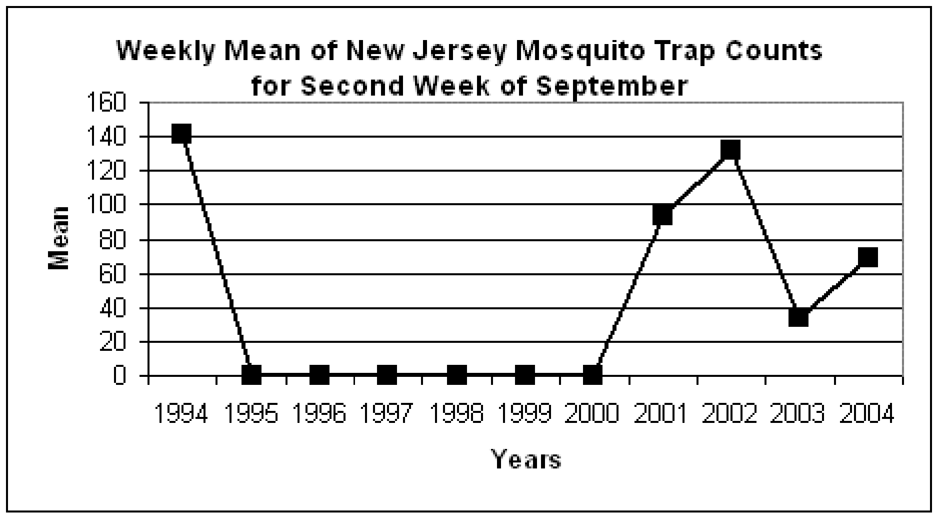
Fifth Week of August	
Year	Mean G
1994	208.69
1995	No Data
1996	No Data
1997	462.12
1998	No Data
1999	No Data
2000	154.16
2001	650.63
2002	64.56
2003	59.79
2004	71.87



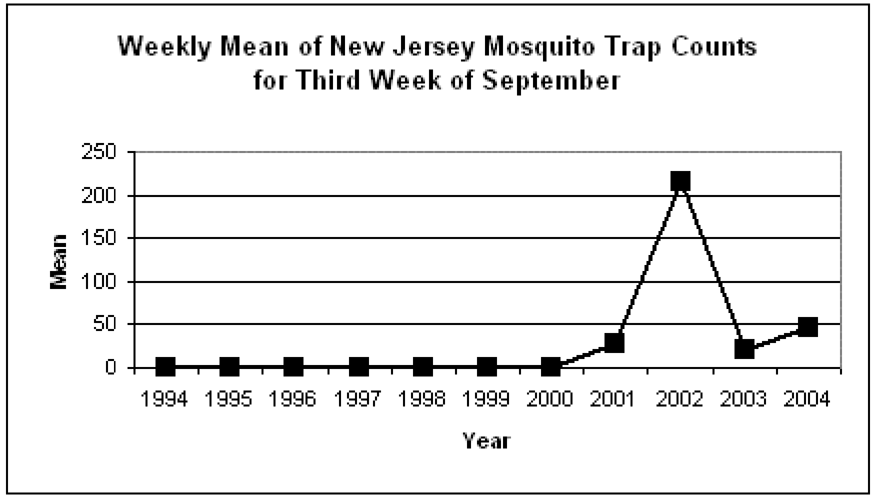
Sixth Week of August - First Week of September	
Year	Mean G
1994	70.46
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	139.98
2001	245.09
2002	86.67
2003	50.59
2004	72.5



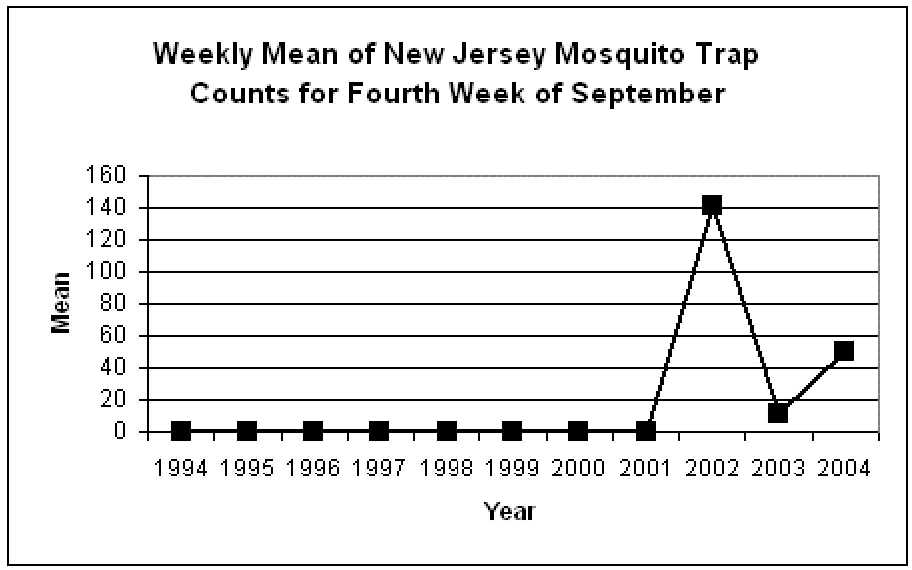
Second Week of September	
1994	141
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	No Data
2001	93.53
2002	131.43
2003	34.26
2004	69.41



Third Week of September	
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	No Data
2001	26.92
2002	215.22
2003	20.91
2004	45.67



Fourth Week of September	
1994	No Data
1995	No Data
1996	No Data
1997	No Data
1998	No Data
1999	No Data
2000	No Data
2001	No Data
2002	140.9
2003	11.65
2004	49.82



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